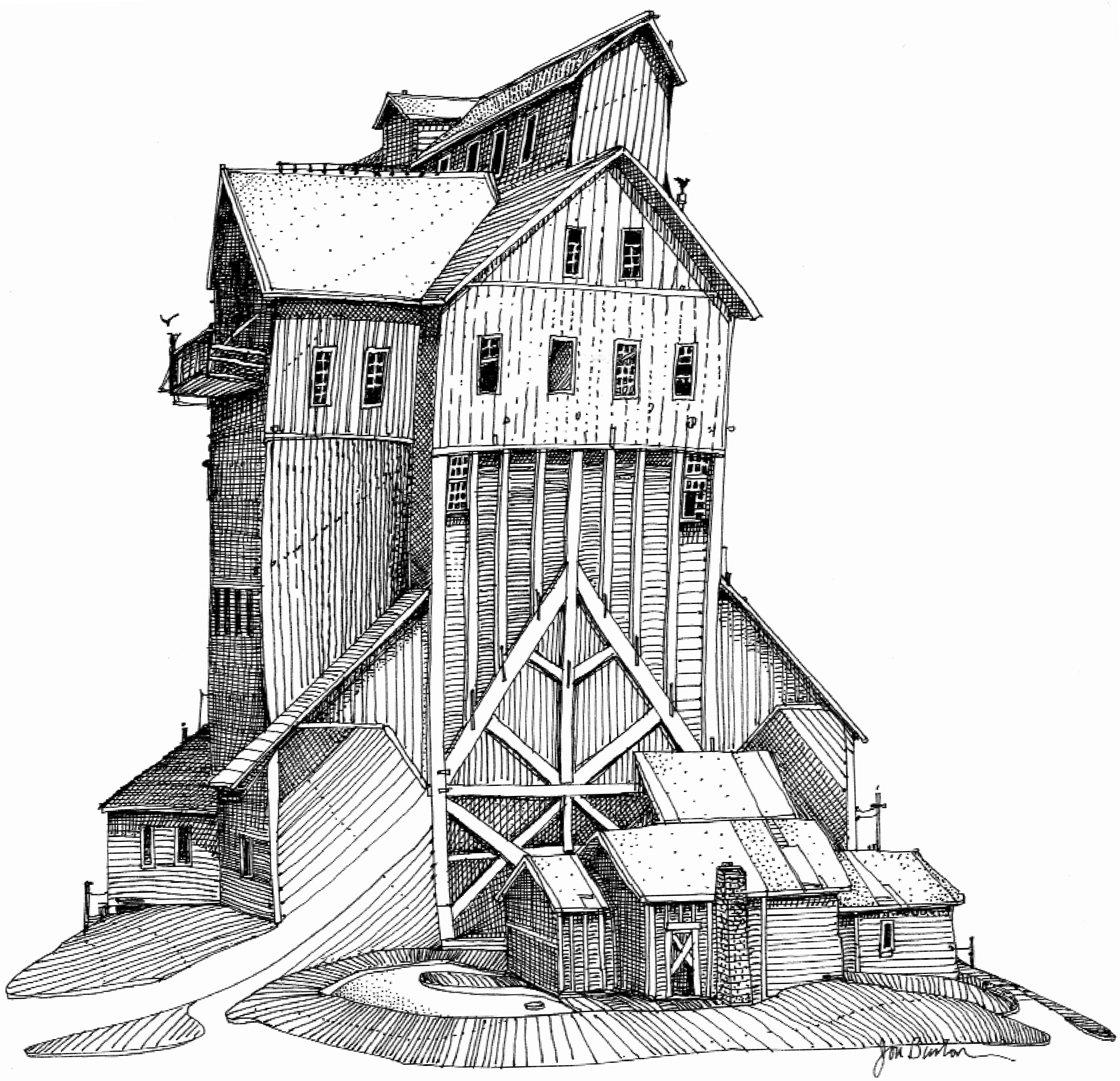
Mining & Milling

The Story of Park City

8TH GRADE SCIENCE CURRICULUM



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Park City Rotary Çlub

Summit County Recreation,
Arts and Parks Program

The Underdog Foundation

Dear Teachers,

We hope that you will enjoy the 8th grade science curriculum and use it with your students to teach major physical and chemical concepts. Each lesson is keyed to the Utah Science Core Curriculum to help you deliver science instructions. Our curriculum includes history sections to provide the students with the appropriate background knowledge and get them excited about their hometown of Park City which was the unique setting for the science of mining and mineralogy. This goes along with our belief in an interdisciplinary approach which provides students with a more holistic knowledge and will empower them in future research projects.

Almost all of the lesson plans allow for adjustments and provide you with different options, depending on the progress of your class. You can teach the entire curriculum within three weeks, or you can extend it to six weeks by slowing down the pace and reducing the workload. Please feel free to contact the Park City Historical Society & Museum with any questions you might have.

Sincerely,

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Introduction

Today, most people know Park City as a ski resort town. However, this only covers the most recent past. In the early days, Park City was known for its mines. Silver was first discovered in the area in 1868, and soon thousands of miners arrived seeking their fortunes. At one time there were as many as 300 mines in operation, with more than 1,000 miles of underground tunnels.

Discover what treasures can be found in Park City's ground, how mining equipment and machinery worked, and what chemical reactions took place in making dynamite and lighting a carbide lamp. Within this curriculum, we hope to teach you about Park City's minerals, the materials and tools needed to mine for precious metals, and also a little bit of Park City's wonderful history.

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Lesson Plan Overview

Lesson 1: Mining and the Growth of Park City

Students discuss the influence of the Park City Mining District on the growth and development of Park City. This will provide students with the historical background knowledge for the following science lessons.

Time: 45 minutes
25 minutes reading and debrief
20 minutes exercise

Lesson 2: Park City's Valuable Minerals

Students learn how minerals were formed in Park City's mountains and observe the properties of these minerals and their uses.

Time: 90 minutes
20 minutes introduction and reading
30 minutes map exercise
40 minutes Rock and Mineral Specimens exercise

Lesson 3: Gold Rush vs. Silver Fever

Students read about placer deposits, placer mining, and hard rock mining, then answer study questions. They perform an experiment to separate valuable minerals from a mixture of sand and minerals, simulating how prospectors panned for gold. Students prepare a lab report of their observations.

Time: 90 minutes
30 minutes reading and questions
15 minutes reading debrief
45 minutes lab

Lesson 4: Powder Monkeys

Students complete a brief reading about dynamite. In small groups, students are given practical problems about setting dynamite and coached to think critically about the physical results of explosions and how dynamite releases energy.

Time: 90 minutes
45 minutes reading
45 minutes class discussions

Lesson 5: My Head’s On Fire!

Students learn about the result of the chemical reaction between calcium carbide and water in a carbide lamp. Students describe the reactants and products, and balance the chemical equation.

Time: 60 minutes
40 minutes introduction and reading
20 minutes classroom exercise

Lesson 6: The Power of Steam

Students read historical information on steam powered mining equipment and perform an experiment. Students describe how a steam engine works and discover how such an engine powered a mine hoist, a pump and a locomotive in Park City.

Time: 90 minutes
25 minutes talk/demonstration
45 minutes lab
20 minutes homework extension

Lesson 7: Milling It Over

Students develop hypotheses about the milling processes taking place inside 19th century mill buildings. Students will use the stamp battery model to figure out how ore is crushed.

Time: 90 minutes
30 minutes group work
10 minutes lecture
40 minutes model assembly
10 minutes stamp battery exercise

Lesson 8: Do We Have Silver Yet?

Students learn which chemical reactions took place in smelters to produce pure metal. Students recognize the difference between physical and chemical changes by using critical thinking skills and writing chemical equations.

Time: 45 minutes

Lesson 9: Culminating Activity

Students complete one culminating project.

Time: 90+ minutes

Teacher Guide

LESSON 1

Mining and the Growth of Park City

Lesson Overview

Students discuss the influence of the Park City Mining District on the growth and development of Park City. This will provide students with the historical background knowledge for the following science lessons.

Time: 45 minutes: 25 minutes reading and debrief, 20 minutes exercise.

Learning Objectives

Students will be able to:

- Name at least three positive results of mining on the Park City economy.
- Name two negative effects of mining on the natural environment.

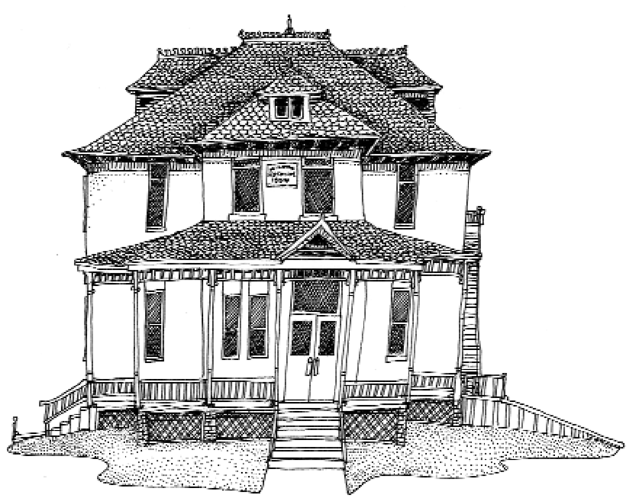
Core Curriculum Requirements

Standard 2: Students will understand that energy from sunlight is changed to chemical energy in plants, transfers between living organisms, and that changing the environment may alter the amount of energy provided to living organisms.

Objective 3: Analyze human influence on the capacity of an environment to sustain living things.

Materials

- Reading - "Mining and the Growth of Park City"
- Overhead projector



Instructional Sequence

1. State objectives and write them on the board.

Ask: How many of you remember being in second grade when you learned about Park City's history? Did you visit the Park City Museum and ride in the stagecoach? Let students share some of their experiences.

Explain: We will review Park City's mining history in order to provide context for the upcoming science lessons.

2. Copy, distribute and assign the reading "Mining and the Growth of Park City" in class.

Use the overhead projector to display the Park City photos in the text.

3. Debrief the reading with the following questions. Validate the learning points, and use photos to make your point.

What made Park City different from other mining towns?

What was it like being a miner in Park City?

What were the effects of mining on Park City's economy and environment?

4. Assign the Checkpoint activity as class exercise or homework.

Learning Points

- Mining boosted Park City's economy, and the town grew tremendously during the first few years.
- Positive results of mining were: jobs for new immigrants; miners earned higher wages than average Americans; other businesses in Park City thrived.
- Negative effects of mining: noise; forests were cut down; milling pollution.

LESSON 1

Mining and the Growth of Park City

People came from all over the world to work in the Park City mines. Within a few years of the first discovery of silver, over 500 men had come to work in the mines. Businessmen soon followed to supply the miners with food, clothing, timber, and other services. In 1879, over 3,000 people lived in Park City, and by 1892 the population had reached 7,000. By then, 119 businesses were in town, including blacksmiths, shoemakers, and saloons (Fig. 1.1). After the Great Fire of 1898 destroyed most of the town, citizens rebuilt the town into a thriving community once again, usually an uncommon occurrence in a mining town.

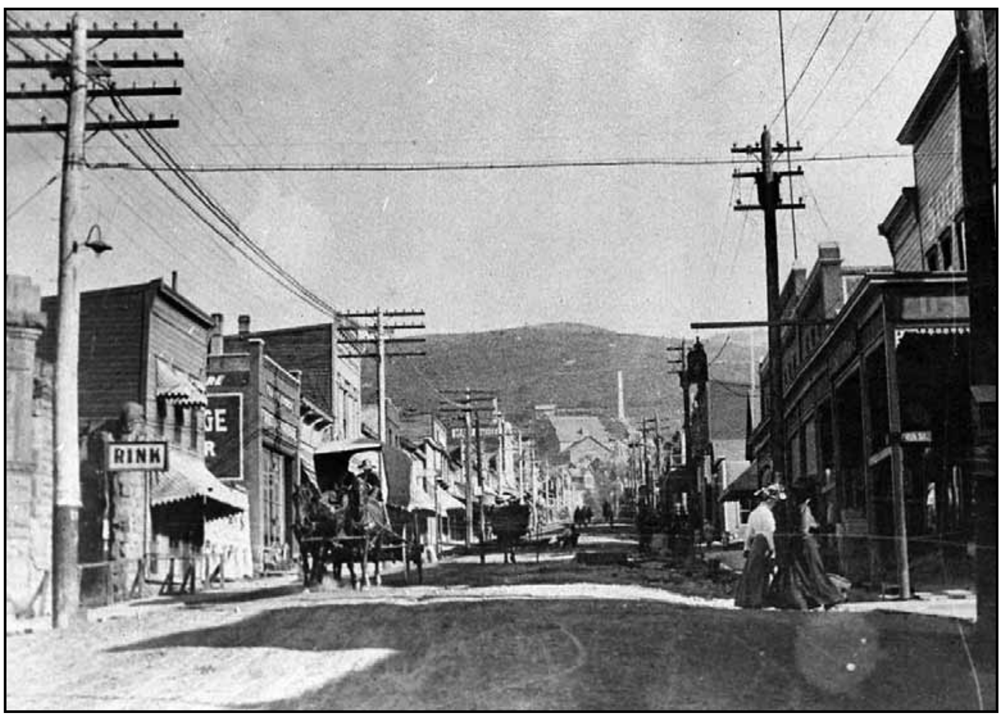


Fig. 1.1 By the 1890s, many businesses crowded Main Street, turning the small mining camp into a booming town.

Image courtesy Kendall Webb Collection

Unlike other mining towns where miners would come in, earn some money and move on, many people who came to Park City settled here. They built homes, saved money to send for their families, and joined a growing community. Miners earned between $2.75 and $3.00 per day for a 10-hour shift, higher wages than the average American at the time. Immigrants came from Northern and Western Europe to work jobs that required few skills and little knowledge of English. Miners also moved here from other mining areas, such as Virginia City, Nevada and Cornwall, England (Fig. 1.2).

Fig. 1.2 Miners of varying skills came to Park City from all over the world.

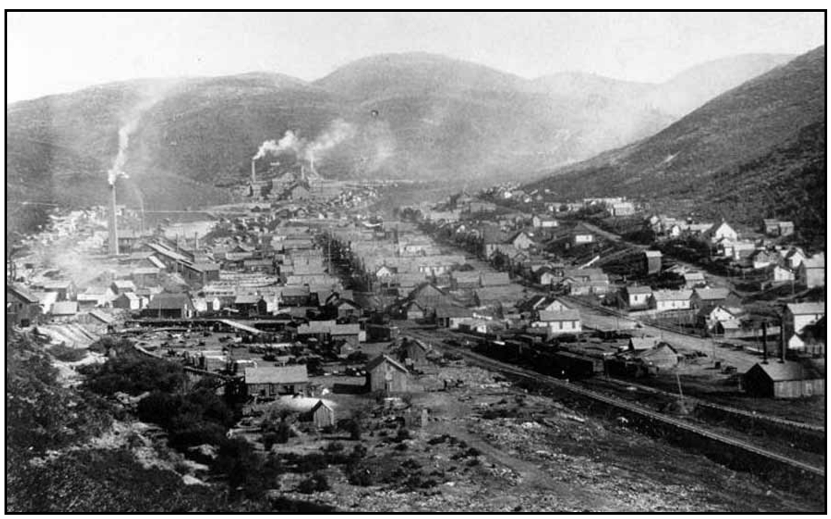


Fig. 1.3 The many mills in Park City caused a lot of pollution.

Being a booming mine town, Park City had its share of problems. The many mills that were necessary for mining polluted Park City's air (Fig. 1.3), and the crushing equipment inside the mills produced constant noise that echoed off the canyon walls.

Fig. 1.4 The steam locomotives that transported the ore out of the mines used coal to fuel the engines.

Park City's mountains used to be thickly forested with many varieties of trees. However, most of the trees were cut down to make mine timbers, build businesses and houses, and burned as fuel for the mines' steam engines. Tons of wood and coal were burned daily. Locomotives that hauled the ore to the smelters also required the use of natural resources (Fig. 1.4).

As time went on, mining companies addressed these issues, making Park City a more desirable place to live. Park City's viable mining economy continued well into the 1940s, providing Parkites with a good life and a decent living.

Fig. 1.5 Skiers put on their skis next to the Thaynes Shaft house and head frame at what is now Park City Mountain Resort.

Unfortunately, Park City's mines did not enjoy the same success that most of the country did after World War II. Imports resulting in depressed metal prices caused many of the mines to close, and people moved away. The remaining mines merged to form the United Park City Mines Company (UPCM). UPCM was responsible for opening the first big ski resort in Park City in 1963, called Treasure Mountains (now Park City Mountain Resort).

Tourism in the summer as well as in the winter has taken over as the economic engine for Park City. You can see remnants of Park City's mining past all over Park City today (Fig. 1.5).

NOTES

Checkpoint

Fill in the Blanks

1. In 1879, over 3,000 people lived in Park City, and by 1892, the population had reached _________.

2. Among the _____ businesses in Park City were ____________, ____________ and ____________.

3. A miner's salary ranged from ________ to ________.

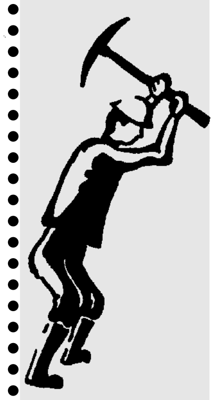
4. Miners worked _______ hours each day.

5. Miners came from many European countries, for example from ____________,____________, ____________, ____________ and ____________.

6. Mining caused bad pollution in Park City: the _______ was bad, and ________ were cut off to ___________________________ and ____________________ for the mines' steam engines.

7. The ____________________ of ________ destroyed most of the town, but the citizens rebuilt the community within 18 months.

8. After the Second World War, many of the mines closed. The remaining mines merged to form the ____.



Checkpoint

Answer Guide

Fill in the Blanks

1. In 1879, over 3,000 people lived in Park City, and by 1892, the population had reached **7,000**.

2. Among the **119** businesses in Park City were **blacksmiths**, **shoemakers** and **saloons**.

3. A miner's salary ranged from **$2.75** to **$3.00**.

4. Miners worked **10** hours each day.

5. Miners came from many European countries, for example from **Ireland**, **England**, **Sweden**, **Norway** and **Germany**.

6. Mining caused bad pollution in Park City: the **air** was bad, and **trees** were cut off to **build houses and businesses** and **burned as fuel** for the mines' steam engines.

7. The **Great Fire** of **1898** destroyed most of the town, but the citizens rebuilt the community within 18 months.

8. After the Second World War, many of the mines closed. The remaining mines merged to form the **United Park City Mines Company**.

LESSON 1

LESSON 2

Teacher Guide

Park City's Valuable Minerals

Lesson Overview

Students learn how minerals were formed in Park City's mountains and observe the properties of these minerals and their uses.

Time: 90 minutes: 20 minutes introduction and reading, 30 minutes map exercise, 40 minutes Rock and Mineral Specimens exercise.

Learning Objectives

Students will be able to:

- Describe how Park City's mineral deposits were formed.
- Name the valuable minerals commonly found in Park City's mountains.
- Write chemical symbols for these minerals and describe their uses.
- Compare the weights of ore (containing minerals) with waste rock (containing no valuable minerals).

Core Curriculum Requirements

Standard 3: Students will understand the processes of rock and fossil formation.

Objective 1: Compare rocks and minerals and describe how they are related.

a. Recognize that most rocks are composed of minerals.

b. Observe and describe the minerals found in rocks.

c. Categorize rock samples as sedimentary, metamorphic, or igneous.

Standard 4: Students will understand the relationships among energy, force, and motion.

Objective 2: Examine the force exerted on objects by gravity.

a: Distinguish between mass and weight.

Prerequisite: Crystal Chemistry, Chapter 2, Section 5, from *Chemical Interactions*, Science Explorer Prentice Hall textbook or the mineral section of *Science Explorer Inside Earth*.

Materials

- Galena, iron pyrite, and sphalerite specimens
- Waste rock specimens
- Quartz specimens
- Reading - "Park City's Valuable Minerals"
- Computer and Powerpoint projector
- Color geologic map of Snyderville Basin (on CD) (Districts outside Park City can obtain a local geologic map.)
- Graduated Cylinders • Scales • Paper & pencils

Instructional Sequence

1. State objectives and write them on the board.

Ask: How many of you know that Park City began as a mining camp and that there were silver mines in Park City's mountains? Ask for a show of hands. Which valuable metals were found in Park City's mines?

Explain: Silver, lead, zinc, some copper and gold. We're going to start a unit on the physical and chemical changes of the minerals found in Park City.

2. Introduce new vocabulary. See Glossary in the back.

Sandstone	Geologic map	Extrusive rock	Limestone
Mineralization	Hydrothermal	Shale	Fault lines
Fossiliferous	Magma	Galena	Silt
Igneous rock	Pyrite	Sedimentary rock	Mineral
Metamorphic rock	Ore	Vein	Weight
Iron pyrite	Crystallize	Quartz	Intrusive rock

3. Give a talk based on the reading "Park City's Valuable Minerals."

Option: Copy, distribute, and assign the reading in class or for homework.

4. Use the computer and Powerpoint projector to display the Geologic Map of Snyderville Basin.

Students complete the Checkpoint exercise. Review the answers to the Checkpoint exercise.

5. Divide the class into groups of 5 students. Distribute mineral and waste rock specimens.

Students complete the “Rock & Mineral Specimens” exercise.

6. Debrief the exercise with the following questions. Validate the learning points.

What conclusions can you draw about the weight of valuable ore versus worthless rock?

What tips could you give a prospector about finding valuable minerals in Park City?

Learning Points

- Ore with valuable minerals weighs more than waste rock.
  There are no visual signs that igneous rock contains valuable minerals.
- If rock is seen with iron staining from the iron (Fe) in iron pyrite, it means that ore containing silver, lead and zinc could be present.
- Rocks with a metallic glint could be valuable, but this is not guaranteed.

BONUS ASSIGNMENT

Throughout the curriculum there is potential for extra credit by completing the Chemical Profile Chart provided in the back. Copy and distribute the Chemical Profile Chart. Students complete #1-6 on the Chemical Profile Chart.

LESSON 2

Park City's Valuable Minerals

You've seen the red rock called **sandstone** (Fig. 2.1) in many parts of Utah. There is plenty of sandstone in Snyderville Basin and Park City, although it may not all be red in color. Sandstone is composed of many sand-size minerals and rock grains, most notably quartz.

Limestone (Fig. 2.2) is usually whitish, tan, or gray. It is mostly made of a mineral called calcite (calcium carbonate, $CaCO_3$) and commonly formed by sea animals leaving their shells in ancient sea beds. Limestone that contains fossils is called **fossiliferous**. Some of the limestone found in Park City is fossiliferous.

Shale (Fig. 2.3) is rock that was formed from clay or mud, so it's usually black or dark brown. Some shale breaks up into thin layers that clatter when you throw them. If you go hiking in Empire Canyon, you'll see lots of shale.

All these layers of rock were formed at different points in time, millions of years ago. At one point **magma** from deep inside the earth started pushing up from below. Magma is molten rock, with a consistency of toothpaste. The rocks were folded by compressive tectonic forces from deep underground. Cracks and fissures developed. As the molten rock hardened, **hydrothermal** waters that remained flowed up through these cracks and fissures and formed **veins**, which included valuable minerals.

Fig. 2.1 Sandstone is a sedimentary rock made up mostly of quartz. It is common in Park City and the Snyderville Basin.

How Exactly Did Mineralization Occur?

A **mineral** is a naturally occurring substance formed through geological processes that has a characteristic chemical composition and specific physical properties. Minerals **crystallize** as the liquids, in which they are dissolved, cool.

Think of a pot of boiling water containing salt. As the water heats up, the salt will dissolve. According to the same principle, minerals were deposited in rock. Minerals, dissolved in hot water (hydrothermal solutions) that had been derived from magma or some other source, moved through the rocks. The confining pressure of the rock bodies maintained the heat of the water.

However, whenever the water encountered cracks and fissures in the **sedimentary rock**, the pressure dropped because the water had more room to spread out. The change in pressure, along with the movement of the water, resulted in a drop in temperature. This created the perfect environment for these minerals containing zinc, lead, iron, silver and gold, to crystallize and stay behind inside cracks and fissures. This process is called **mineralization**.

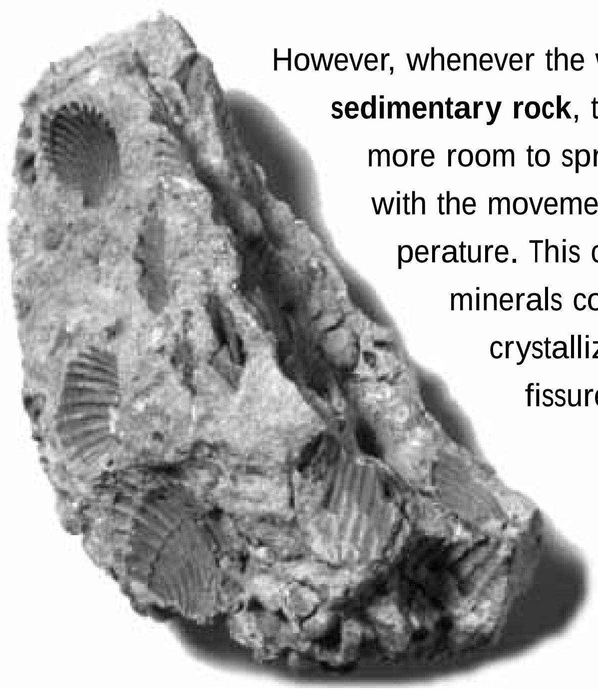


Fig. 2.2 Like sandstone, limestone is a sedimentary rock. Limestone is made mostly of the mineral calcite. It is common in Park City and the Snyderville Basin.

Fig. 2.3 Shale is a very fine-grained sedimentary rock. It is usually made up of either clay or mud.

Valuable Minerals

The valuable minerals in Park City's mountains include:

Galena, PbS, a compound of lead and sulfur, with silver often substituting for the lead

Sphalerite, ZnS, a compound of zinc and sulfur

Tetrahedrite, $Cu_{12}Sb_4S_{13}$ a compound of copper, antimony, and sulfur, with silver often substituting for the copper or the antimony

Quartz, SiO_2 is the most common mineral on earth. Quartz can be found in all mineral environments and in almost all rock types. In Park City, quartz is often associated with waste rock.

The most precious metals in Park City's mountains were:
Silver, Ag, in abundant quantity
Gold, Au, which was very rare

Silver was always found together with galena, sphalerite, or tetrahedrite. The presence of **iron pyrite** (FeS_2), also called fool's gold, might mean there were valuable minerals nearby, since pyrite crystallized out of hydrothermal solutions at the same time as the valuable minerals. The valuable minerals and worthless rocks were called **silver ore.** A vein is a deposit of metallic ore which fills fissures in native rock. Below you will find an example of a silver ore vein. (Fig 2.4.) The miners located the veins by looking for an outcrop.

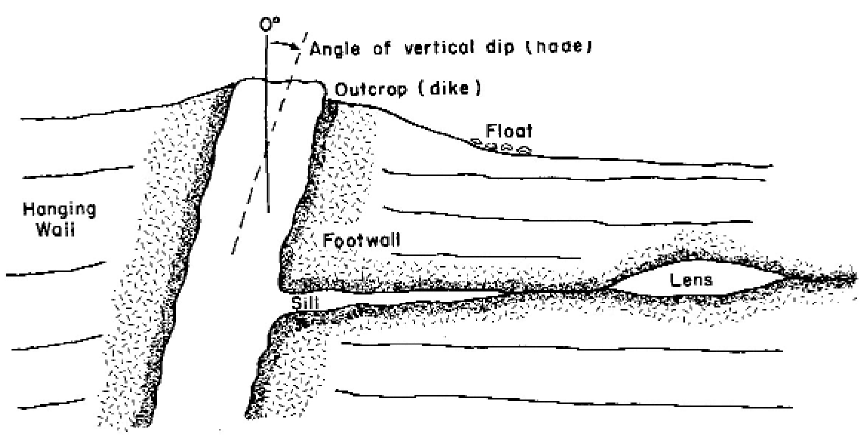


Fig. 2.4 A vein of silver ore.
Image courtesy Western Mining.

NOTES

Checkpoint

Are valuable minerals under your house?

The **geologic map** shows major rock formations on the surface of Park City and Snyderville.

1. Find the red color – This is where the **igneous** or **intrusive rock** is. Intrusive rock is another name for rock that has formed from molten magma below the surface.

2. Find the fault lines – Mineralization occurs here. The magma came up through the cracks and fissures in the sedimentary rock, and minerals crystallized out of the hot acidic water created by the magma.

3. Find the orange color – This is where hot lava flowed out onto the surface and cooled to form igneous rock. This is called **extrusive rock** formation.

4. Find your neighborhood in the map. What color is it?______________________

5. Write the name of the surface rock under your neighborhood. _____________

6. How many other types of rock are underneath the surface rock you live on?

____

Hint: The Map Key shows the age of the layers of sedimentary rock from the youngest to the oldest in descending order.

Bonus Points:

Q: What is the youngest surface rock? In what parts of the Snyderville Basin is it located?

A: _______________________

____

____

____

____

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Q: What is the oldest surface rock? Where in Snyderville Basin is it located?

A: _______________________

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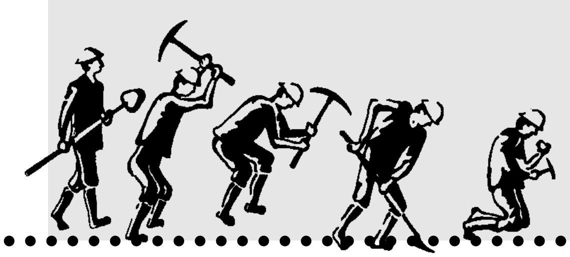


LESSON 2

Checkpoint

Answer Guide

Are valuable minerals under your house?

The **geologic map** shows major rock formations on the surface of Park City and Snyderville.

1. Find the red color – This is where the **igneous** or **intrusive rock** is. Intrusive rock is another name for rock that has formed from molten magma below the surface.

2. Find the fault lines – Mineralization occurs here. The magma came up through the cracks and fissures in the sedimentary rock, and minerals crystallized out of the hot acidic water created by the magma.

3. Find the orange color – This is where hot lava flowed out onto the surface and cooled to form igneous rock. This is called **extrusive rock** formation**.**

4. Find your neighborhood in the map. What color is it?________________________

5. Write the name of the surface rock under your neighborhood. ______________

6. How many other types of rock are underneath the surface rock you live on?

____

(Note: Students' answers will vary depending on where they live.)

Hint: The Map Key shows the age of the layers of sedimentary rock from the youngest to the oldest in descending order.

Bonus Points:

Q: What is the youngest surface rock? In what parts of the Snyderville Basin is it located?

A: Silt and gravel (the yellow sections) are the youngest surface rocks, located along State Road 224 in the flatter section of Park City and in Park Meadows. Silt and gravel were deposited by weathering and erosion of the surrounding higher elevations.

Q: What is the oldest surface rock? Where in Snyderville Basin is it located?

A: Quartz-rich sandstone (the purple sections) is the oldest surface rock. It's located in the mountainous areas that include Park City Mountain Resort and Deer Valley. Notice that many fault lines are located in this area.

LESSON 2

LAB ACTIVITY

Rock & Mineral Specimens

Pick up the specimen of galena in one hand and the specimen of waste rock or quartz in your other hand.

Which one feels heavier? Weigh each specimen.

Find the volume of each specimen, using a graduated cylinder and water.

Volume = amount of water displaced by specimen

Calculate the density of each specimen. Density = mass/volume

Make observations about the specimens and complete the chart below.

	Mass	Volume	Density	Color	Texture	Scratch Test
Galena PbS						
Silver Ore						
Pyrite FeS_2						
Waste Rock						
Quartz SiO_2						

What conclusions can you draw about the density of galena versus waste rock?

____

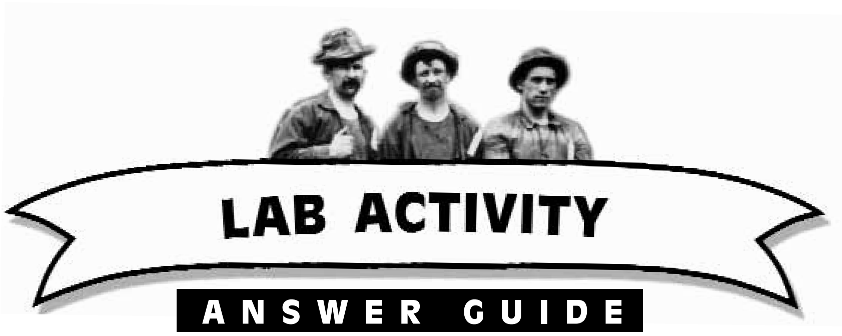
____

What would you tell a prospector in Park City's mountains to look for when searching for valuable minerals?

____

____

LESSON 2



Rock & Mineral Specimens

Pick up the specimen of galena in one hand and the specimen of waste rock or quartz in your other hand.

Which one feels heavier? Weigh each specimen.

Find the volume of each specimen, using a graduated cylinder and water.

Volume = amount of water displaced by specimen

Calculate the density of each specimen. Density = mass / volume

Make observations about the specimens and complete the chart below.

"Answers will be determined by specimen"

	Mass	Volume	Density	Color	Texture	Scratch Test
Galena PbS			**7.4 to 7.6**			
Silver Ore			**About 7.5**			
Pyrite FeS_2			**5.02 to 5.2**			
Waste Rock			**About 2.8**			
Quartz SiO_2			**2.65**			

What conclusions can you draw about the density of galena versus waste rock?

It is denser than waste rock.

What would you tell a prospector in Park City's mountains to look for when searching for valuable minerals?

He should look for iron-stained outcrops in the mountains.

LESSON 3

Teacher Guide

Gold Rush vs. Silver Fever

Lesson Overview

Students read about placer deposits, placer mining, and hard rock mining, then answer study questions. They will perform an experiment to separate valuable minerals from a mixture of sand and minerals, simulating how prospectors panned for gold. Students prepare a lab report of their observations.

Time: 90 minutes: 30 minutes reading and questions, 15 minutes reading debrief, 45 minutes lab

Learning Objectives

Students will be able to:

- Describe placer mining and panning for gold.
- Explain why gold accumulated in placer deposits.
- Describe hard rock mining.
- Explain the difference between hard rock mining and placer mining.

Core Curriculum Requirements

Standard 1: Students will understand the nature of changes in matter.
Objective 1: Describe the chemical and physical properties of various substances.
b. Classify substances based on their chemical and physical properties.

Standard 3: Students will understand the processes of rock and fossil formation.
Objective 2: Describe the nature of the changes that rocks undergo over long periods of time
b. Describe the role of energy in the processes that change rock materials over time.
e. Identify the role of weathering of rocks in soil formation.

Prerequisite: Crystal Chemistry Chapter 2, Section 5, from *Science Explorer Chemical Interactions*, a Prentice Hall textbook.

Materials

- Reading - "Gold Rush vs. Silver Fever"
- Lab activity
- Classroom exercise
- Mixture of sand, quartz, and minerals: 1 cup per group
- Water in large tubs or children's wading pools
- Enough tin pans for each group of students
- Paper & pencils

Note: You can order inexpensive gold pans and gold-bearing sand online from the Mineral Information Institute. Go to www.mii.org and click on the "panforgold" link. This link also includes detailed instructions on how to set up the gold panning activity in your classroom.

Instructional Sequence

1. State objectives and write them on the board.

Ask: Who knows when gold was discovered in California? Ask for a show of hands.

Explain: 1848. This resulted in the California Gold Rush, and the following gold prospectors were called '49ers.

Ask: Who knows when silver was discovered in Park City?

Explain: 1868. You could have called it 'Silver Fever,' because there were so many men who came to Park City to seek their fortunes. In this unit, we're going to learn about gold and silver prospecting, and how they are different from each other. You'll learn how to pan for gold and why it works.

2. Introduce new vocabulary. See Glossary in the back.

Sediment	Single jacking	Gravel	Erosion
Double jacking	Placer deposit	Assayer	Troy ounce
Placer	Assay	Hard rock mining	

3. Copy, distribute and assign the reading "Gold Rush vs. Silver Fever" in class or for homework, and ask students to answer the questions on the classroom exercise sheet.

4. Debrief the reading by going through the questions on the Checkpoint worksheet.

Stress the key learning points:

- Over time, the forces of water and weather (erosion) broke down rock to release gold.
- Panning for gold worked, because the valuable metal (gold) was more dense than the waste rock (sand or quartz).
- Hard rock mining is more difficult than placer mining, because the valuable minerals are still inside the rock (silver ore). Lots of men with heavy equipment had to work hard to get the silver ore out of the ground.
- Park City prospectors used dynamite to break up rock to find silver ore.
- Assayers crushed silver ore into tiny particles; then used chemicals and hot furnaces to find out how much silver was in the rock.

5. Run the lab activity "Panning for Gold."

Students will separate valuable minerals in a sample of riverbed sand by using the technique of "panning for gold."

Give each group a mixture of sand (quartz) and minerals (about 1 cup each).

Tell students to use the lab sheet to guide their experiment.

Help groups answer the questions on the lab sheet.

6. Debrief the lab activity with the entire class by reviewing the results.

Compare the densities:	Gold – 15.3 - 19.3	Silver – 10.5
	Galena – 7.4 to 7.6	Iron Pyrite – 5.02 to 5.2

Bonus Assignment

Students read the History Box "A Bandana Marked the Spot" and visit the Park City Museum to learn more about how silver was discovered in Park City.

LESSON 3

Gold Rush vs. Silver Fever

You've probably heard of the Gold Rush of 1849 when prospectors headed west to seek their fortunes in California. They panned for gold in streams and rivers. It was a joyous moment when they found a gold nugget or even little flakes of the yellow metal, because that very evening they could sell their nugget for cash or pay for a meal with gold dust.

In 1868, Park City's prospectors didn't have it quite so easy. The precious metal they sought was deep underground. Moreover, it was locked inside silver ore. Galena and Sphalerite were visible, but the valuable silver metal wasn't even visible to the naked eye. This type of mining is called **hard-rock mining**.

Miners in Park City used dynamite to blow up rock. Using a method called **single jacking**, a lone miner would make a deep hole in a rock with a hammer and a drill steel (Fig. 3.1). Even though the prospector swung the hammer 30 times a minute and used many sharp drill steels, it would take hours to drill a hole deep enough to set dynamite.

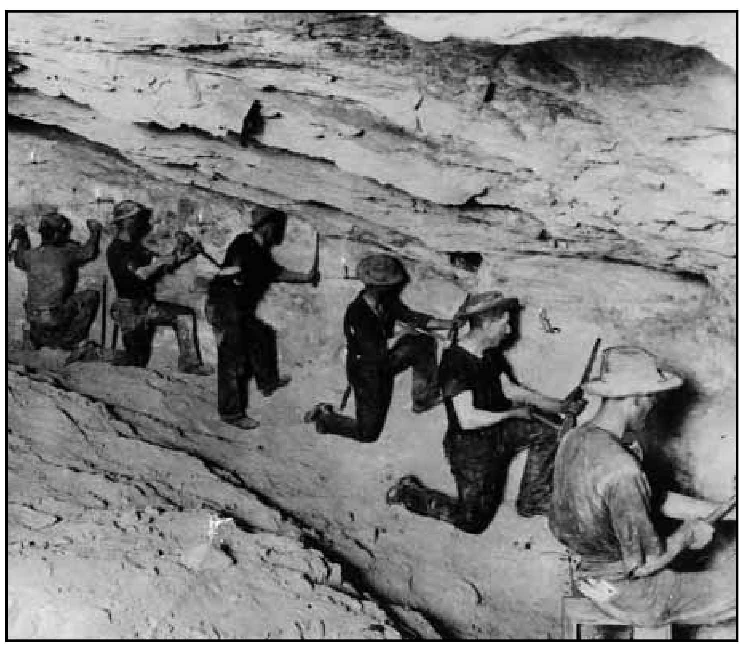


Fig. 3.1 Early miners single jacking in Park City. Once they had a deep enough hole, dynamite could be inserted to blow up the rock.

It was called **double jacking** when two miners worked together. One miner would hold and turn the drill steel while the other swung a larger hammer that weighed about eight pounds. Working twice as fast as a miner single jacking, they could blow up the rock in half the time.

Sorting through the rubble after a dynamite explosion, miners could never tell the value of silver ore just by looking at it. An **assay** had to be done to determine the value of the ore. A specialized worker, called an **assayer**, crushed the rock into very fine material and used chemicals and a hot furnace to separate the valuable metals from the waste rock (Fig. 3.2).

Prospectors would wait with excitement for the assayer's answer, which was always given in **troy ounces** per ton of ore. Samples from the first silver strike in Park City were assayed at more than 90 troy ounces of silver per ton. That figure meant that the claim was a good one. The Silver King Mine's claim was first assayed at 390 troy ounces of silver per ton. On the basis of an assayer's results prospectors could sell their claims. The average silver ore in the Park City Mining District was only 16 troy ounces per ton. However, it also contained valuable lead and zinc.

Fig. 3.2 Assayers separated the valuable metals from the waste rock to determine the amount of silver per ton of ore. The assay revealed the value of a mine claim.

Placer Mining

Why was panning for gold in California so much easier than hard rock silver mining in Park City? It's simple. Nature had done all the work! Over time rain and ice broke up the rock in California that held the precious metal. Bits of gravel grated on other bits of gravel. Air, water, natural acids, and dissolved minerals slowly eroded mountains. Since water rolled downhill, the bits of gold ended up as erosional deposits in streams and rivers.

A place where prospectors found gold was called a **placer deposit**. "**Placer**" literally means "sand banks" and is a good indication of where these deposits are found. Gold dust, flakes, or nuggets tended to pile up in riverbeds, on sandbars, along riverbanks, and in cracks in large rocks. The heavier metal would settle in the lower bed of the stream and lighter rocks like quartz and sand would settle above.

A prospector only had to scoop the sand with his pan, which looked like a pie plate. He would tilt the pan back and forth in order to wash away the lighter material, leaving only the heavier gold (Fig. 3.3). This process was called "panning for gold."

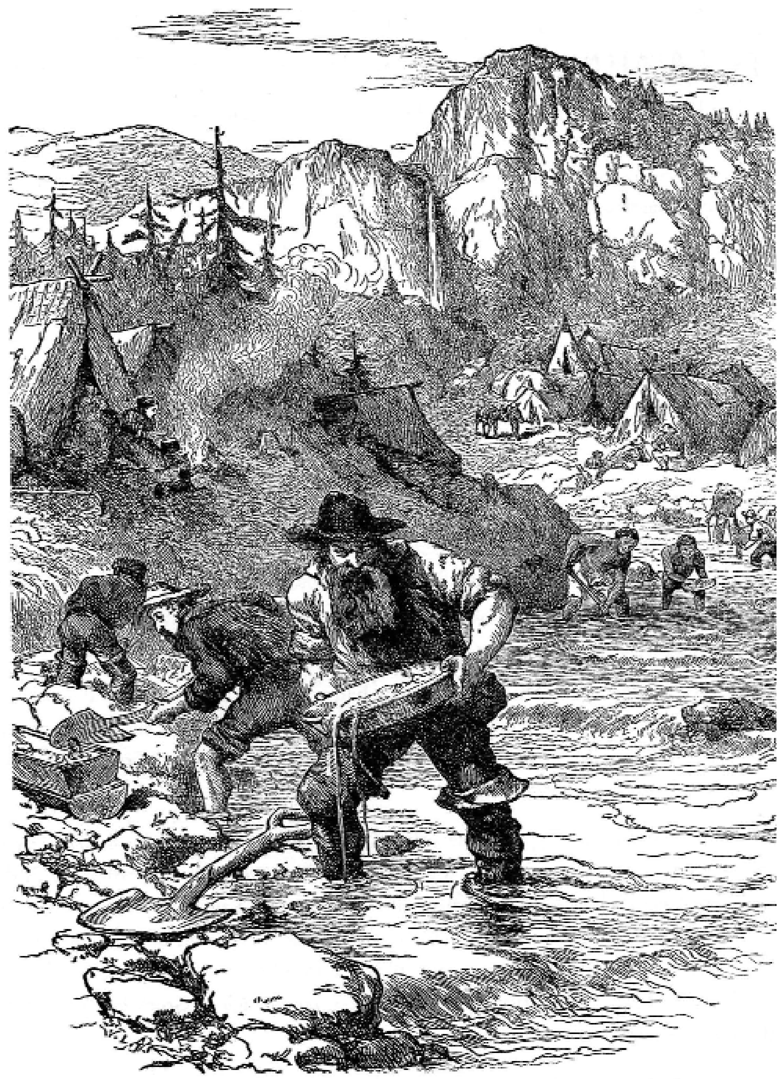


Fig. 3.3 Placer miners used a simple pan to find gold in rivers and stream beds.

Image courtesy The Mining Camps Speak.

NOTES

Checkpoint

When we say "nature broke up the rock" to form placer deposits of gold, we mean that the process of **erosion** took place. This happens when water and weather break up the rock over eons of time. Circle the natural forces that break up rock.

Wind	**Rain**
Double jacking	**Acids**
Lightning strikes	**Pounding by heavy machines**
Gravel grinding on gravel	
Mudslides	**Rock slides**
Dynamite	**Ice**

Read the statements below. Each pair has one sentence describing hard rock mining and one describing placer mining. Put the numbers in the correct categories.

1. Uses a pan to sort through rock.
2. Uses dynamite to break through rock.

3. Valuable minerals are found in hard rock.
4. Valuable minerals are found in riverbeds and streams.

5. The name is based on minerals being locked inside of rocks.
6. The name comes from the places where minerals were found.

7. Requires lots of men, time and money to get new wealth.
8. Can make a prospector wealthy right away.

9. The value of a find was visible to the naked eye.
10. The value of a find was determined by an assay.

Placer Mining	Hard Rock Mining

LESSON 3

Fill in the Blank:

1. ______ deposits are places in riverbeds and streams where gold dust, flakes, or nuggets pile up.

2. Hard rock mining is more difficult than placer mining, because the valuable minerals are locked inside _________.

3. Park City prospectors used _________ to blow up rock.

4. The reason panning for gold worked was because the gold was ________ than sand and quartz, so it would settle at the bottom of the prospector's pan.

5. A person who figured out how much silver was in a sample of silver ore was called an _________.

6. To estimate the value of a silver strike, the rock would be ________ into very fine pieces. ___________and a hot furnace were used to separate the valuable minerals from the waste rock.

Checkpoint

Answer Guide

When we say "nature broke up the rock" to form placer deposits of gold, we really mean erosion took place. This happens when water and weather break up the rock over eons of time. Circle the natural forces that break up rock.

Wind	Rain
Double jacking	Lightning strikes
Acids	Pounding by heavy machines
Gravel grinding on gravel	
Mudslides	Rock slides
Dynamite	Ice

Read the statements below. Each pair has one sentence describing hard rock mining and one describing placer mining. Put the numbers in the correct categories.

1. Uses a pan to sort through rock.
2. Uses dynamite to break through rock.
3. Valuable minerals are found in hard rock.
4. Valuable minerals are found in riverbeds and streams.
5. The name is based on minerals being locked inside of rocks.
6. The name comes from the places where minerals were found.
7. Requires lots of men, time and money to get new wealth.
8. Can make a prospector wealthy right away.
9. The value of a find was visible to the naked eye.
10. The value of a find was determined by an assay.

Placer Mining	Hard Rock Mining
1,4,6,8,9	2,3,5,7,10

Fill in the Blank:

1. **Placer** deposits are places in riverbeds and streams where gold dust, flakes, or nuggets pile up.

2. Hard rock mining is more difficult than placer mining, because the valuable minerals are locked inside **silver ore**.

3. Park City prospectors used **dynamite** to blow up rock.

4. The reason panning for gold worked was because the gold was **heavier** than sand and quartz, so it would settle at the bottom of the prospector's pan.

5. A person who figured out how much silver was in a sample of silver ore was called an **assayer**.

6. To estimate the value of a silver strike, the rock would be **crushed** into very fine pieces. **Chemicals** and a hot furnace were used to separate the valuable minerals from the waste rock.

LESSON 3

Gold Rush vs. Silver Fever

Read through "Gold Rush vs. Silver Fever" and answer the following questions.

1. **What is placer mining?**

____

____

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2. **What is hard rock mining?**

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3. **Why did *panning for gold* work?**

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4. **How did Park City prospectors find silver ore?**

____

____

____

5. **Why was hard rock mining so much more difficult than placer mining?**

____

____

____

6. **What did assayers do?**

____

____

____

CLASSROOM EXERCISE

ANSWER GUIDE

Gold Rush vs. Silver Fever

Read through "Gold Rush vs. Silver Fever" and answer the following questions.

1. What is placer mining?

A: A place where prospectors found gold was called a placer deposit. Placer literally means "sand banks" and is a good indication of where these deposits are found. Gold dust, flakes or nuggets tended to pile up in riverbeds, on sandbars, along riverbanks, and in cracks of large rocks. Prospectors panned for gold in streams and rivers.

2. What is hard rock mining?

A: Park City's mountains have valuable minerals hidden inside the rock. Prospectors drilled holes with a drill steel and a hammer to set dynamite. The dynamite was used to blow up the rock to get to the minerals.

3. Why did *panning for gold* work?

A: The heavier metal settled in the lower bed of a stream or river, and lighter rocks like quartz and sand settled above. The prospector scooped sand and gravel into a pan and sorted it, looking for the heavier gold and using water to wash away the lighter materials.

4. How did Park City prospectors find silver ore?

A: Prospectors looked for outcrops of veins which might contain valuable minerals. The prospector sampled these veins and sometimes would develop exploration shafts using dynamite.

5. Why was hard rock mining so much more difficult than placer mining?

A: Hard-rock mining was much harder. The precious metal was deep underground and locked inside silver ore, not even visible to the naked eye.

6. What did assayers do?

A: The assayer figured out how much silver was in a sample of silver ore. He crushed the rock into very fine pieces, and used chemicals and a hot furnace to separate the valuable minerals from the waste rock.

Panning For Gold

You will use the technique of *panning for gold* to separate minerals from regular sand as it can be found in river beds.
Each group receives different minerals and a cup of sand.

Questions to consider:
What are the names of the minerals?

How did you recognize the minerals?

Compare the densities of the minerals you found?

Mineral Names	How did you recognize the minerals?	Density

What do the densities tell you about how to separate different kinds of rocks and minerals?

____

____

____

____

LAB ACTIVITY

ANSWER GUIDE

Panning For Gold

You will use the technique of *panning for gold* to separate minerals from regular sand as it can be found in river beds.
Each group receives different minerals and a cup of sand.

Questions to consider:

What are the names of the minerals?

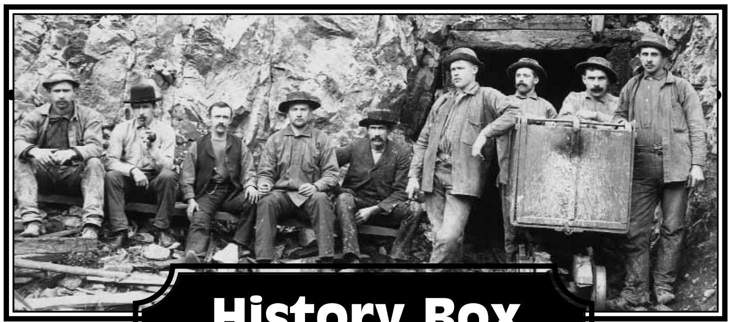
How did you recognize the minerals?

Compare the densities of the minerals you found?

Mineral Names	How did you recognize the minerals?	Density
GOLD	Yellow color, fairly soft, very heavy	15.3 - 19.3
GALENA	Lead-gray color, shiny surface, soft, very heavy, metallic luster	7.2 to 7.6
SILVER	Silvery, gray-white color, fairly soft, very heavy, metallic luster	10.5
IRON PYRITE	Fairly dark yellow, hard, very heavy, very fragile, metallic luster	5 to 5.2
QUARTZ	Colorless when pure, otherwise whole range of colors, very hard, light, transparent luster	2.65

What do the densities tell you about how to separate different kinds of rocks and minerals?

Minerals which have significantly different densities are easy to separate. An example would be gold and quartz, or galena and quartz. Minerals with densities which are similar are more difficult to separate.



History Box

A Bandana Marked the Spot

Colonel Patrick E. Connor
Image courtesy of the Utah State Historical Society.

In 1868, on a cold October day, three Union soldiers took a day off from their duties at Camp Douglas in Salt Lake City and hiked from Big Cottonwood Canyon to Bonanza Flats. These soldiers were prospectors who had been encouraged to look for valuable minerals by their commander, Col. Patrick E. Connor. He had orders from the Union government to watch over the Mormons during the Civil War. Connor believed that a silver or gold strike would bring a more diverse population to the Utah territory.

The tired, thirsty soldiers stopped to rest and looked around for the treasure they had hiked so far to find. They saw signs of galena and copper - dark staining on the side of the rock walls across the valley. Their excitement was soon interrupted by snow-laden clouds and an icy wind moving over the Flats. With a blizzard about to descend, they gathered up their ore samples, wrapped a bandana around a dead pine tree, and stuck it in the ground to mark their claim.

Later, assayers valued the ore at more than 90 troy ounces of silver per ton. This claim, called the Flagstaff after its simple marker, would become the first mine to ship lead and silver ore from Park City in 1871. Today, you can see the place the soldiers stopped at to rest if you ski the Pinyon Ridge trail at Park City Mountain Resort. From the tops of Jupiter Peak and McConkey's Bowl you can overlook Bonanza Flats where the mining boom in Park City began.

Flagstaff Mine

LESSON 3

NOTES

LESSON 4

Teacher Guide

Powder Monkeys

Lesson Overview

Students complete a brief reading about dynamite. In small groups, students are given practical problems about setting dynamite and coached to think critically about the physical results of explosions and how dynamite releases energy.

Time: 90 minutes: 45 minutes reading, 45 minutes class discussions

Learning Objectives

Students will be able to:

- Describe the chemical composition of dynamite and write the molecular formula for dynamite.
- Explain how powder monkeys set dynamite.
- Explain the physical results of explosions and how dynamite releases energy.

Core Curriculum Requirements

Standard 1: Students will understand the nature of changes in matter.

Objective 3: Investigate and measure the effects of increasing or decreasing the amount of energy in a physical or chemical change, and relate the kind of energy added to the motion of the particles.

a. Identify the kinds of energy given off or taken in when a substance undergoes a chemical or physical change.

d: Cite evidence showing that heat may be given off or taken in during a chemical change.

Prerequisite: Chemical Reactions, Chapter 1, from *Science Explorer Chemical Interactions*, a Prentice Hall textbook. Blasting section, from *Drills and Mills*, by Will Meyerricks.

Materials

- Reading - “Powder Monkeys”
- Paper & pencils
- “The Powder Monkey’s Problem” classroom exercise

Instructional Sequence

1. State objectives and write them on the board.

Explain: You learned that Park City prospectors used dynamite to break up rock and retrieve the silver ore. Today we're going to learn how dynamite works, and how miners set dynamite inside the mines so it exploded in a fairly safe manner.

2. Introduce new vocabulary. See Glossary in the back.

Powder monkey	Sticking tommy
Hoistman	Spitter
Drift	Silica
Blasting cap	Fuse

3. Copy, distribute and assign the reading "Powder Monkeys" for homework or in class.

Debrief the reading by reviewing the answers to the checkpoint questions.
Option: Give a talk based on the reading and assign the Checkpoint in class.

4. Divide the class into groups of 5 students to do the classroom exercise.

Either pose open questions and ask students: What is going on in this picture? And why? What would you like to learn about this picture?
Or students use the worksheet and discuss "The Powder Monkey's Problem."
Allow 20 minutes for discussion.

Debrief the activity after 20 minutes, copy and distribute the answers.
Tell groups to compare their answers with the new picture. Allow 5 minutes.
Debrief the entire class using the “classroom exercise” answer sheet.

Bonus Assignment

Students complete #7 - 10 on the Chemical Profile Chart provided in the back.
Or students read the History Box “A Dynamite Disaster.”

LESSON 4

Powder Monkeys

Imagine working every day in a place where you could get hurt or even killed. All the mining jobs in Park City were dangerous, but the **powder monkey's** job was probably the most hazardous.

Powder monkey was a nickname for a miner who handled dynamite. His job was to set the dynamite in the holes miners drilled at the end of horizontal tunnels. During this task, he used **fuses** and **blasting caps** to prepare the dynamite for a huge, controlled explosion.

Fig. 4.1 Ascanio Sobrero discovered nitroglycerin in 1847.

How was dynamite invented?

In 1847, an Italian chemist named Ascanio Sobrero (Fig. 4.1) mixed **glycerin** ($C_3H_8O_3$) with **sulfuric acid** (H_2SO_4) and **nitric acid** (HNO_3). Glycerin is a clear, somewhat thick liquid, sometimes used in soap. The two acids are dangerous and harmful. The result of mixing these three reactants is a compound called nitroglycerin ($C_3H_5N_3O_9$). It is extremely dangerous. Why? Because any kind of bump or knock would make the liquid explode. For many years anyone who worked with nitrogylcerin was thought to be foolish, because the explosive was so unpredictable.

Then in the 1850s, a Swedish scientist named Alfred Nobel began working on a solution. Mining was very important to the economy, and people wanted a safe way to blow up rock. Nobel wondered how to stabilize the liquid so it could be carried without exploding, and how to blow up the nitroglycerin from a safe distance.

Like any scientist, Nobel tried many things without success. But he finally found a solution that is still used today. He mixed nitroglycerin ($C_3H_5N_3O_9$) with **silica** (SiO_2). This combination made a paste, which he called dynamite (Fig. 4.2).

Fig. 4.2 Dynamite is a powerful explosive that is a mixture of nitroglycerin and silica. It usually comes in the form of a stick.

In 1864, Nobel invented a type of blasting cap to detonate dynamite. The blasting cap is a metal cylinder that is open at one end. Most blasting caps contain a primary explosive that will explode from flame, heat or shock. A fuse was inserted into the open end of the cylinder. To get the fuse to stay in place, a miner would have to pinch the cap to hold the fuse (Fig. 4.3). The blasting cap was then embedded in the dynamite stick (Fig. 4.4). The fuse could be cut in different lengths and lit at one end from two or three feet away. When the fire reached the blasting cap, it would explode, setting off the dynamite.

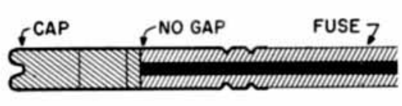


Fig. 4.3 The fuse was inserted into the blasting cap.
Image courtesy Blasters' Handbook

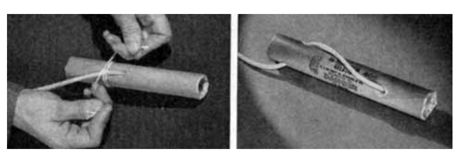


Fig. 4.4 The blasting cap was embedded into the dynamite stick and the fuse tied to the stick.
Image courtesy Blasters' Handbook

The Force of Explosion

When dynamite explodes, heat and gasses are produced. The heat makes the gas expand rapidly producing high pressures. The high pressures force rock to be broken apart. The direction of the force is equal on all sides unless cracks, holes, fissures or weaker materials exist. Then the direction of force will follow the path of least resistance.

Fig. 4.5 The house at 614 Park Avenue was blown up with dynamite to prevent the Great Fire of 1898 from spreading further north.

The Various Uses of Dynamite

Dynamite was used in mining to blast away rock and dig deep mines. People needed the rich resources hidden inside the rock -- for example, lead for ammunition, leaded glass and pottery glazes; copper for pipes and wires; silver for making coins, jewelry, silverware and photographic film.

Dynamite was also used in construction to dig tunnels for roads and foundations for buildings and bridges. Controlled blasts were even used to demolish old or damaged buildings. In fact, during Park City's Great Fire of 1898, miners blew up houses on purpose trying to stop the fire from spreading (Fig. 4.5).

NOTES

Checkpoint

Match the term with its description.

___	1. Powder monkey	a. A material that moves an object, often with pressurized gas.
___	2. Fuse	b. A horizontal tunnel in a mine.
___	3. Silica	c. A mixture of nitro-glycerin & silica.
___	4. Propellant	d. To make a dangerous material less dangerous.
___	5. Stabilize	e. A highly unstable mixture of glycerin & acids.
___	6. Gunpowder	f. A clear, somewhat thick liquid, sometimes used in soap.
___	7. Drift	g. An explosive invented in the 8th century.
___	8. Blasting cap	h. Miner who handled dynamite.
___	9. Dynamite	i. A thin rope with gun-powder that burns slowly.
___	10. Nitroglycerin	j. Something like sand.
___	11. Glycerin	k. A device used to detonate dynamite.
___	12. Gases	l. Products of a dynamite explosion that expand rapidly and whose pressure causes rock to break apart.

LESSON 4

True or False?

____ $C_3H_8O_3 + H_2SO_4 + HNO_3 = C_3H_5N_3O_9$ is a chemical change.

____ $C_3H_5N_3O_9 + SiO_2 = C_3H_5N_3O_9 + SiO_2$ is a physical change.

____ Alfred Nobel was a Swedish inventor.

____ The Nobel Peace Prize is named after Alfred Nobel.

____ Exploding dynamite releases energy in the form of heat. It is an endothermic reaction.

Bonus Questions

When nitroglycerin explodes, what is produced?

How does it behave?

Checkpoint
Answer Guide

Match the term with its description

Answer	No.	Term	Description
h	1.	Powder monkey	a. A material that moves an object, often with pressurized gas.
i	2.	Fuse	b. A horizontal tunnel in a mine.
j	3.	Silica	c. A mixture of nitroglycerin & silica.
a	4.	Propellant	d. To make a dangerous material less dangerous.
d	5.	Stabilize	e. A highly unstable mixture of glycerin & acids.
g	6.	Gunpowder	f. A clear, somewhat thick liquid, sometimes used in soap.
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l	12.	Gases	l. Products of a dynamite explosion that expand rapidly and whose pressure causes rock to break apart.

True or False?

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T $C_3H_5N_3O_9 + SiO_2 = C_3H_5N_3O_9 + SiO_2$ is a physical change.

T Alfred Nobel was a Swedish inventor.

T The Nobel Peace Prize is named after Alfred Nobel.

F Exploding dynamite releases energy in the form of heat. It is an endothermic reaction.

Bonus Question Answers

When nitroglycerin explodes, a large volume of gasses are produced at a high temperature and pressure. The high pressure will break the rock. The force of the explosion will follow the path of least resistance.

LESSON 4

The Powder Monkey's Problem

Miners at the Ontario Mine had to blast a 6' x 8' wall of rock to enlarge a mine drift. They asked the powder monkey to prepare 20 sticks of dynamite, plenty of blasting caps, and a 40-foot long fuse.

Look at the picture and try answering the following questions.

1. **A dynamite explosion produces gas, which acts as a propellant. Will the propellant be more likely to move things through solid rock or a hole? How do you create a hole?**

____

____

____

2. **If you drill holes straight, how will the force move out? What will happen if you drill holes at an angle? Where will the exploded rock tend to go?**

____

____

3. **The miner wants the rubble to end up in a pile in front of the face. What is the best way to drill holes so the dynamite ends up in front? Which dynamite should be set off first, which one last? Indicate the sequence by assigning letters (A-E) to the fuses in the picture.**

____

____

____

4. **If you detonate the dynamite all at once, what will happen to the rock? What if you blow up rock in stages? Where will the propellants push the rock? How does a miner know all the dynamite has blown up?**

____

____

____

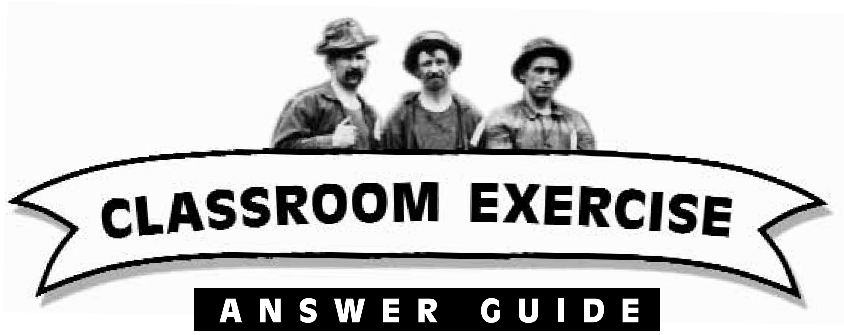
5. **When fuses are lit, the flame and hot gas could blow out the miner's candle. What should he do to ensure he can light the rest of the fuses and has some light to see his way out? Remember there were no flashlights or electric lights in mines in the 1880s.**

____

____

____

LESSON 4



The Powder Monkey's Problem

Miners at the Ontario Mine had to blast a 6' x 8' wall to enlarge a mine drift. They asked the powder monkey to prepare 20 sticks of dynamite, plenty of blasting caps, and a 40-foot long fuse.

Look at the picture, and try answering the following questions.

1. A dynamite explosion produces gas, which acts as a propellant. Will the propellant be more likely to move things through solid rock or a hole? How do you create a hole?

A: The propellant will most likely move things through holes because the direction of force will follow the path of least resistance. One can drill a hole.

2. If you drill holes straight, how will the force move out? What will happen if you drill holes at an angle? Where will the exploded rock tend to go?

A: The force will move straight out of the hole. If you drill holes at an angle, the force and the rock will tend to move up or down depending on the angle.

3. The miner wants the rubble to end up in a pile in front of the face. What is the best way to drill holes so the dynamite ends up in front? Which dynamite should be set off first, which one last? Indicate the sequence by assigning letters (A-E) to the fuses in the picture.

A: The hole in the center A is left empty. The first dynamite to explode is in B. The explosion from B forces the rock inward to A. The C holes go off next. Then, the D holes blow up, with all the rock resting in the center. Finally, the dynamite in the E holes lifts all the blown up rock, and it falls to the ground in front.

4. If you detonate the dynamite all at once, what will happen to the rock? What if you blow up rock in stages? Where will the propellants push the rock? How does a miner know all the dynamite has blown up?

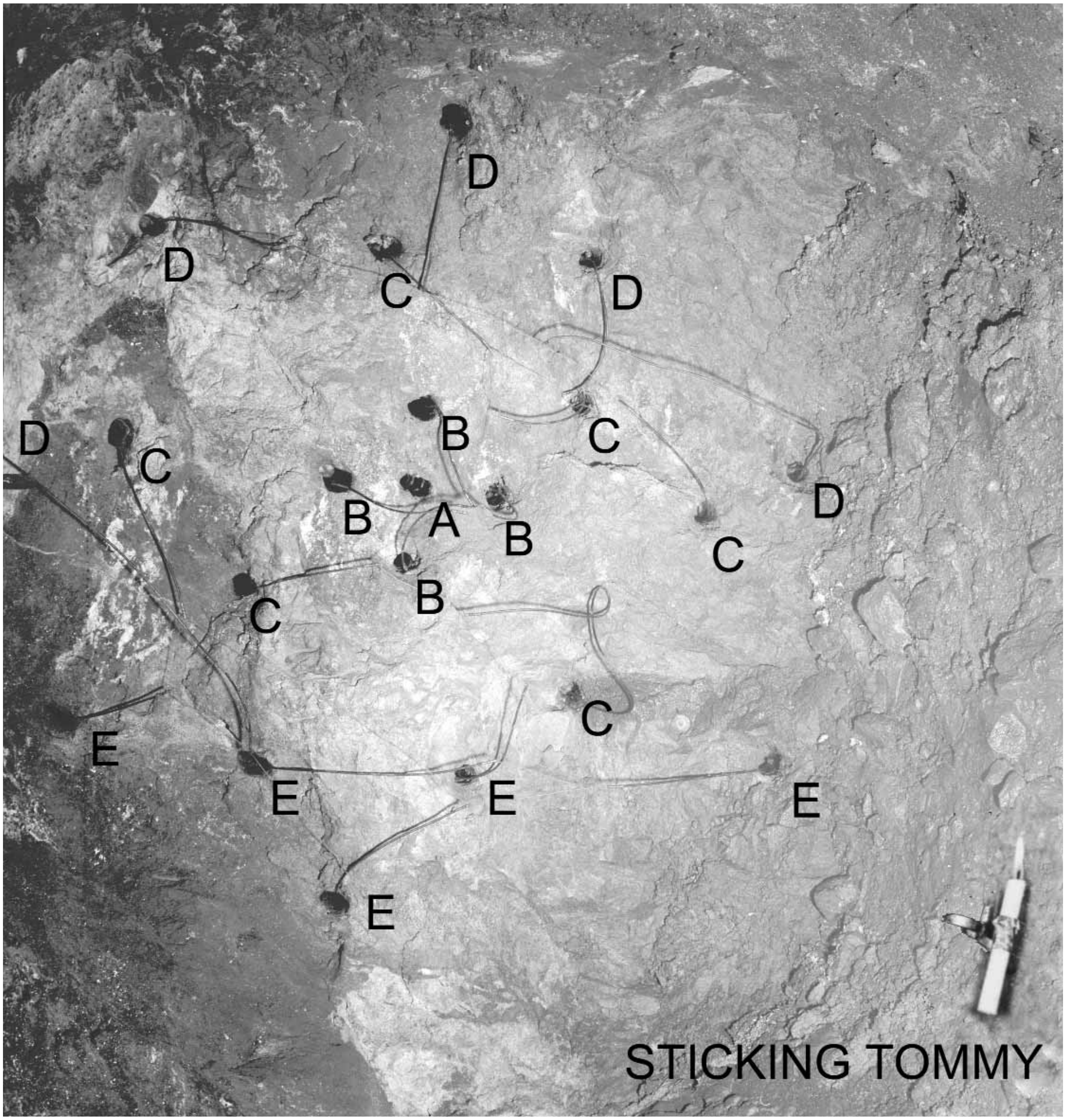
A: The miner cuts fuses of different length so the number of explosions can be counted. That way all the miners know if a stick of dynamite doesn't go off.

5. When fuses are lit, the flame and hot gas could blow out the miner's candle. What should he do to ensure he can light the rest of the fuses and has some light to see his way out? Remember there were no flashlights or electric lights in mines in the 1880s.

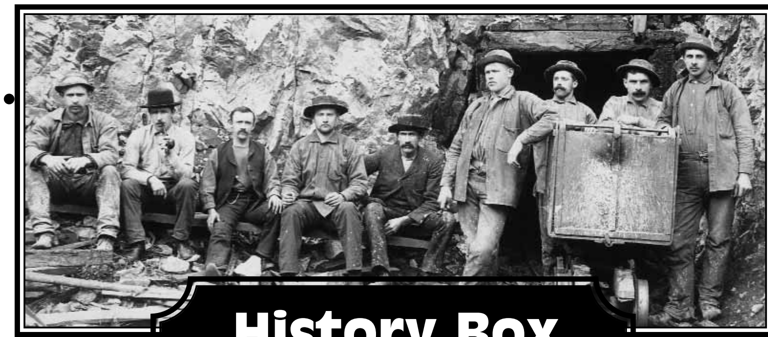
A: A sticking tommy with a candle in it was in the drift so the miner could see his way out. Powder monkeys had at least two candles, one to light the fuse and one to light their escape route. When all the fuses were lit, the powder monkey would yell "Fire in the Hole!" and walk away.

The Powder Monkey's Problem

Answer Guide



LESSON 4



History Box

A Dynamite Disaster

There were few safety measures in place in Park City's early mines. Large amounts of dynamite were stored in the mines' depths, because it was more convenient for the miners. At approximately 11:20 p.m. on July 15, 1902, the powder monkey at the Daly West Mine accidentally dropped a candle or a cigarette into the powder, which caused a huge explosion.

THE PARK RECORD

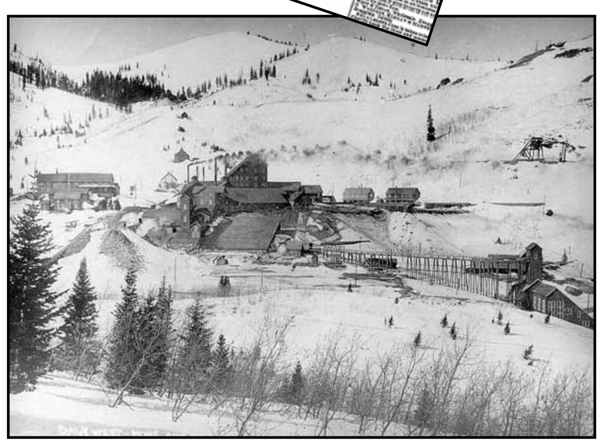
MOST APPALLING ACCIDENT

Thirty-Four Lives Lost Through Explosion of Powder Magazine.

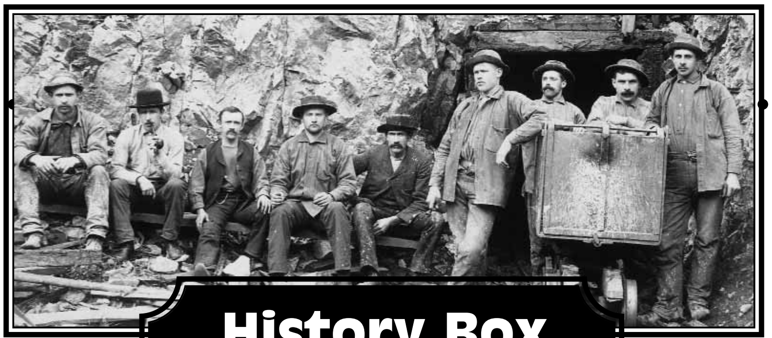
OCCURRED ON DALY WEST 1200

Four Lives Lost in the Attempt at Rescue—Greatest Destruction of Life in History of Park City—Body of Last Victim Recovered This Morning==Full Particulars.

The **hoistman** felt a vibration but did not know what had happened. He lifted the cage to the surface and discovered some pieces of broken timber on it. He then received a signal to lower the cage to the 900-foot level. The station tender came up in the cage and informed everyone that there had been an explosion somewhere below the 900-foot level. For hours, men were lowered into the mine in a search-and-rescue attempt; however, the poisonous fumes were so strong that rescuers themselves became sick.

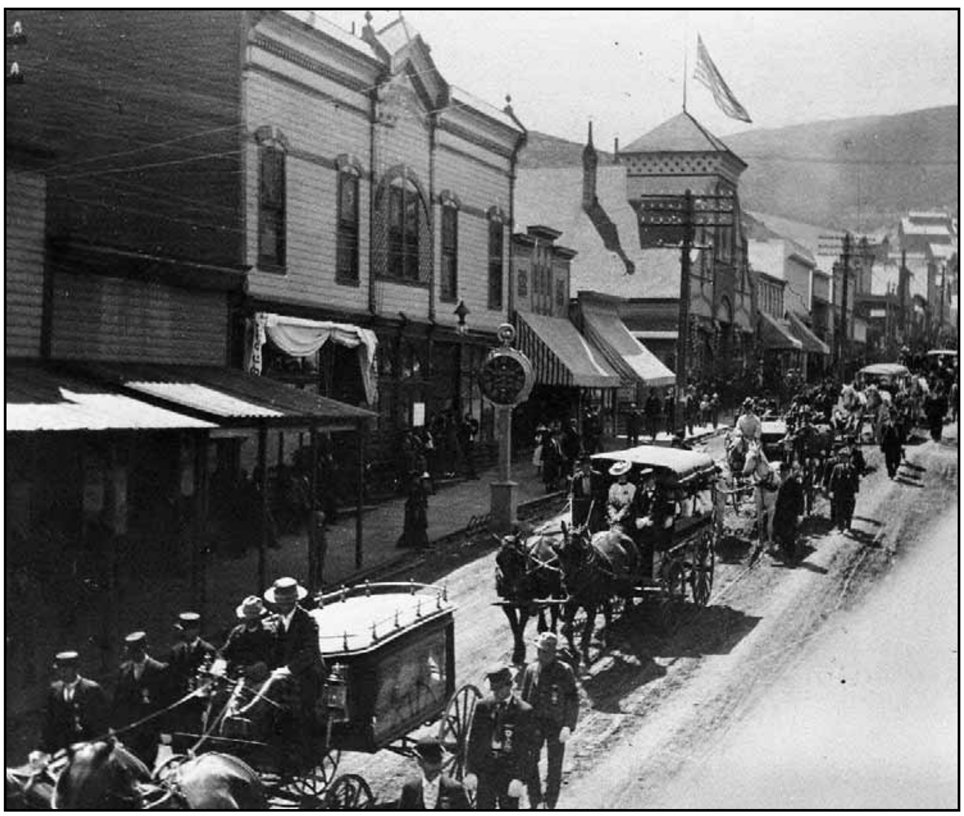


Looking west at the Daly West Mine and Mill.



History Box

Twenty-five men died in the Daly West Mine. Since the natural flow of underground air currents led the fumes into the Ontario's tunnels, an additional nine men died there. As the fumes exited the mines through the Ontario drain tunnel, a horse outside the tunnel dropped dead. With a total of thirty-four men dead, the Daly West accident is the worst mining disaster in Park City's history.



Funeral procession down Main Street after the Daly West mine disaster.

Image courtesy The Fraser Buck Collection

LESSON 4

LESSON 5

Teacher Guide

My Head's On Fire!

Lesson Overview

Students learn about the result of the chemical reaction between calcium carbide and water in a carbide lamp. Students describe the reactants and products and balance the chemical equation.

Time: 60 minutes: 40 minutes introduction and reading,
20 minutes classroom exercise

Learning Objectives

Students will be able to:

- Explain how a carbide lamp works.
- Balance the chemical equation of carbide reacting with water.

Core Curriculum Requirements

Standard I: Students will understand the nature of changes in matter.
Objective 2: Observe and evaluate evidence of chemical and physical change.

a. Identify observable evidence of a physical change.
b. Identify observable evidence of a chemical change.
c. Observe and describe chemical reactions involving atmospheric oxygen.
d. Investigate the effects of chemical change on physical properties of substances.

Materials

- Reading - "My Head's on Fire!"
- Classroom Exercise
- Carbide lamp
- Calcium carbide
- Water
- Paper & pencils

Instructional Sequence

1. State objectives and write them on the board.

Explain: You will learn that in the 1880s miners used candles underground to see in the mines. In 1897, a device called the carbide lamp was invented. This lamp was hooked on a miner's helmet. Would you ever put a chemical reaction on top of your head? Can you think of anyone who does that? Today, we're going to see just how miners could wear a fire on their head (Fig. 5.1).

2. Introduce new vocabulary. See Glossary in the back.

Burner Tip	Valve Control
Carbide Chamber	Water Chamber
Felt	Water Door
Gas Pipe	Water Valve
Reflector	
Striker Assembly	

3. Copy, distribute and assign the reading "My Head's on Fire!"

4. Demonstrate the carbide lamp.

- Explain the cut away diagram of the carbide lamp (Fig 5.3).
- Show the carbide lamp to the students. Introduce the students to the reactants.
- Use the board to balance the equation: $CaC_2 + H_2O = C_2H_2 + CaO$ (Calcium carbide + Water = Acetylene + Calcium oxide)
- Alert students that mixing calcium carbide and water creates an explosive mixture and that therefore you will only talk about the experiment.

5. Copy, distribute and assign students the classroom exercise.

BONUS ASSIGNMENT

Students complete #11-12 on the Chemical Profile Chart provided in the back.
Students read the "History Box" and investigate and report on "Tommy Knockers."

LESSON 5

My Head's On Fire!

Park City was one of the first cities in the state to have electric lights. They were first turned on March 22, 1889. Before that, however, the majority of people used candles. Miners were given three candles at the beginning of their shift, just enough to last 10 hours but not much longer. The mine owners did this so that miners wouldn't take candles home to use at night.

Fig. 5.1 Four miners wearing hard hats with carbide lamps in the New Park Mine.
Image courtesy the Sorensen Collection

In 1892, while working with lime, coal tar and a carbon mixture, Major James T. Morehead and Thomas L. Wilson developed a brownish-grey substance, calcium carbide, that gave off a pungent smelling gas when mixed with water. The gas burned with a bright yellow-white flame, and they called it ***acetylene.***

In 1897, a man named Hooke, who was an inspector of the Hillgrove Coal Mining Fields in New South Wales, had problems seeing underground. Candles and oil lamps were too dim and short-lived, and the electric lights of the day were bulky. Mr. Hooke wanted a small unit that gave bright light and could be recharged without returning to the surface.

Hooke knew a little chemistry – for example that calcium carbide reacts with water to produce clean-burning acetylene gas. So he put it to work in a small brass lamp that burned with a bright, narrow flame and threw light a good twenty feet. The name carbide lamp comes from the chemical reaction that takes place to produce light.

Some modifications have been made over the years, but the "miner's cap" lamps for many years were essentially identical to Hooke's lamp. Within eight years, the first carbide lamp was offered to the public.

The first carbide lamp weighed approximately 4 ounces and was 4 inches high and $1\frac{1}{2}$ inches in diameter.

How Does a Carbide Lamp Work?

The lamp was clipped to the front of the miner's helmet and afforded "hands free" lights. It was an ingenious little contraption made up of two chambers. The lower chamber (carbide chamber) which screwed off from the upper one contained the small cubes of carbide which were like cubes of sugar. A pocket full of these would keep a miner going for a shift.

Fig. 5.2 A miner's carbide lamp - now part of the Park City Museum's collection.

The upper chamber (water chamber) had a little lid (water door) on it and was filled with water. A tap (water valve) protruded into the lower chamber from here. On top was a small valve control which regulated the flow of water into the lower chamber and onto the carbide. This fusion of water and carbide produced a gas which traveled up through the upper chamber and out through a nozzle (gas pipe) on the front of the lamp.

A three inch reflector directed a bright light, which was a great improvement over the candle. When the miner wanted light, he turned on the tap and flicked the flint (striker assembly) and out shot a flame like a mini blow lamp.

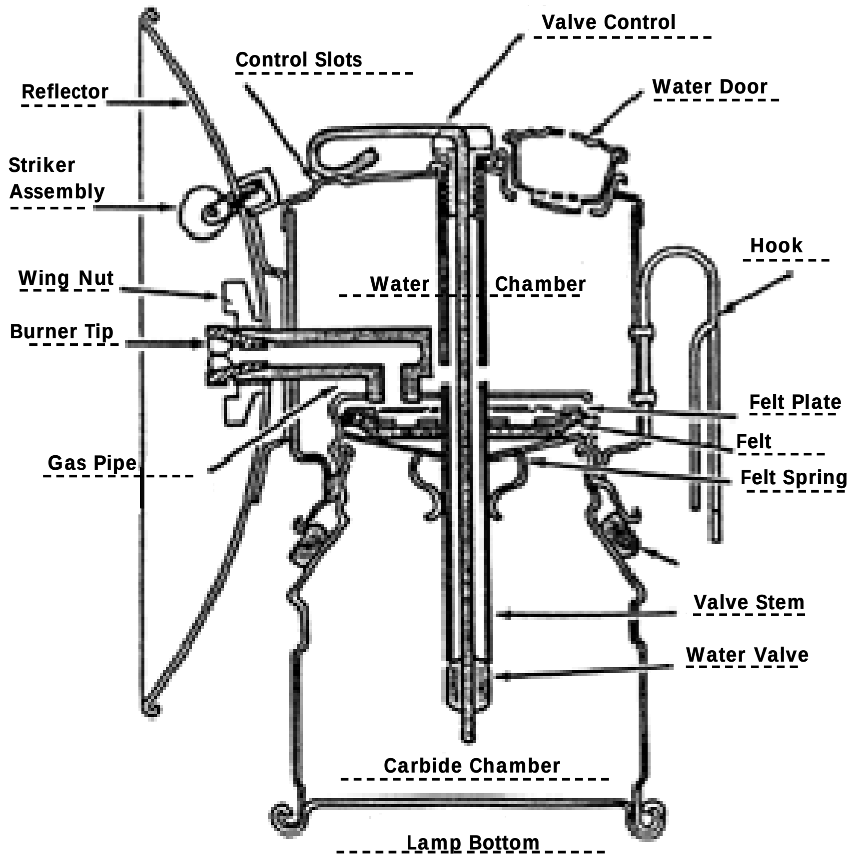


Fig. 5.3
The diagram on the left shows a cut-away view of the carbide lamp.

The Most Important Carbide Lamp Parts

Water Door- small lid with small hinge, lifts up

Water Chamber – holds water

Valve Control – moves along grooves (control slots), sets rate of water flow

Water Valve – hole where water drips onto carbide rocks

Carbide Chamber – holds carbide rocks

Felt – allows gas to pass up from carbide chamber, keeps used (spent) carbide in chamber

Gas Pipe – tube that gas blows out of

Burner Tip – where flame is when lamp is in use

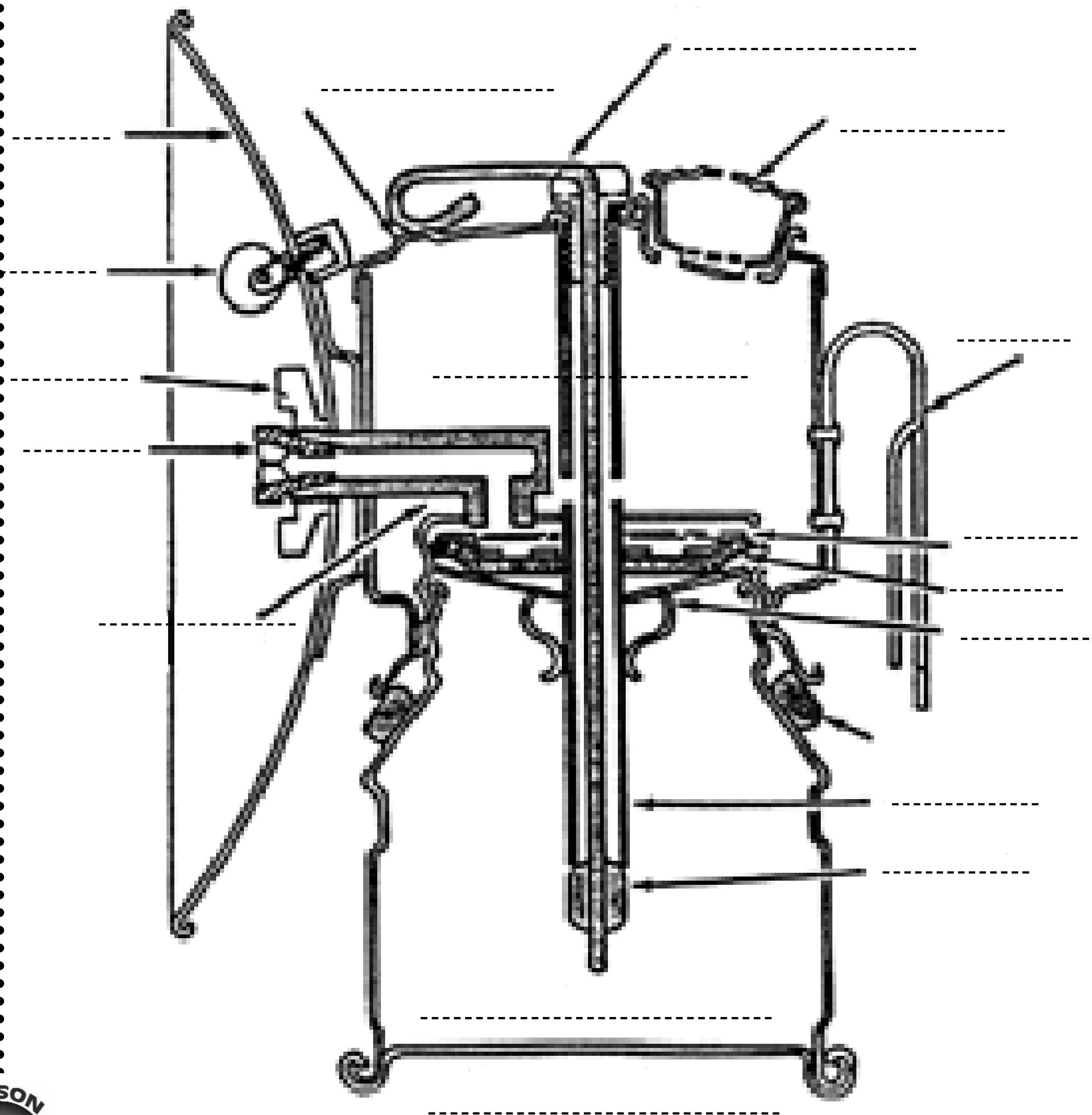
Striker Assembly – has flint rock inside, creates a spark, is attached to reflector

Reflector- magnifies amount of light

NOTES

CLASSROOM EXERCISE

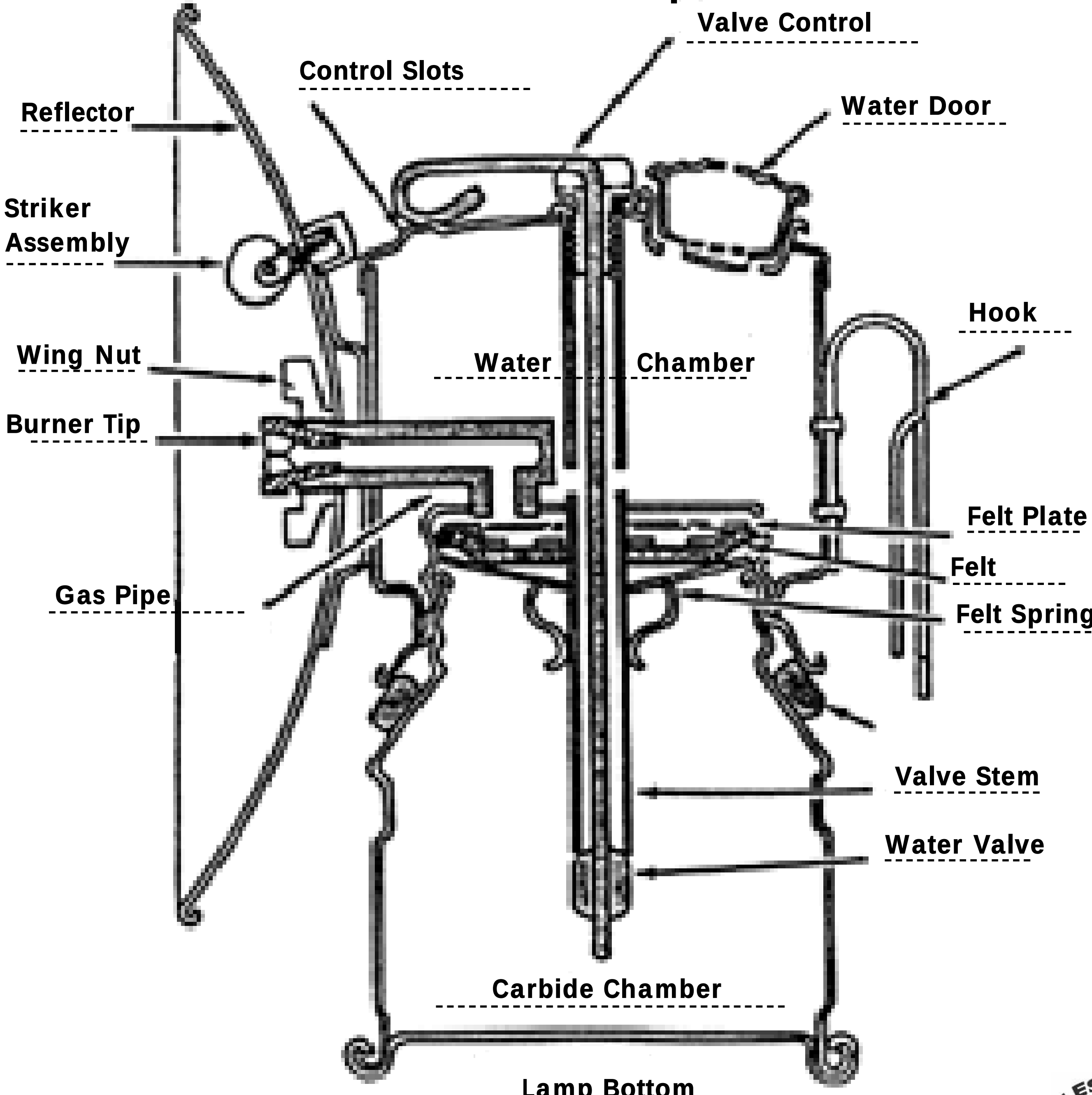
The Carbide Lamp



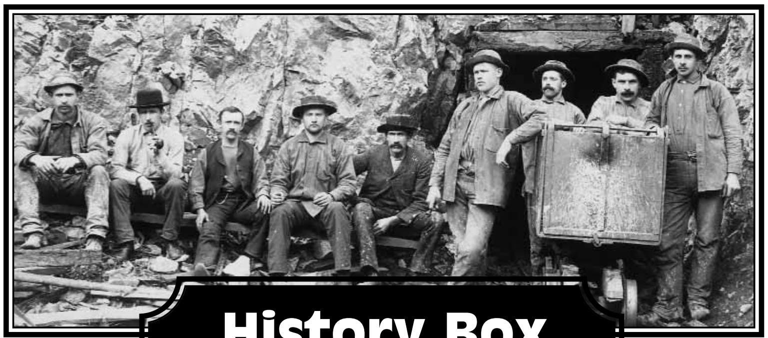
CLASSROOM EXERCISE

ANSWER GUIDE

The Carbide Lamp



LESSON 5



History Box

Tommy Knockers

Miners were very superstitious, and there were certain signs of bad luck, for example women inside the mines, if someone whistled or dropped a tool, or if you heard a howling dog. If a miner's candle blew out, this meant that there was trouble at home; if it was extinguished by water three times, for sure the miner's wife was bothered by someone.

Most miners never gave notice when exactly they would quit their jobs. Many men had revealed their plans of quitting and had been killed or injured during their last shift. This resulted in miners leaving a day earlier than they had originally planned.

Another frightening story is that of an Irishman named Quinn. He swore he had seen a woman on a white horse on the 200 foot level of the old Alliance mine. Supposedly, she had long blond hair and glowing white skin. Legend has it that the poor woman was looking for her husband who had died in a mine accident years earlier.

The most notorious creatures were "Tommy Knockers." They made themselves noticed through strange sounds in the walls, similar to drilling, which surely meant bad luck for the miners who heard it.

TOMMY KNOCKERS

'ave you 'erd of the Tommy Knockers

We go down in the shafts with our buckets
With 'earts which nothing fazes,
Each man with a candle to light the way
Through the drifts an 'winzes an' raises.
An' the stale air smells of powder
An' the mine is full of sound,
But 'tis only the tap of a Knocker
That makes our 'earts rebound.

It's their tap, tap, tap Like sounds of tiny liners,
Just a tap, tap, tap From souls of dead miners.
For they're locked in the rock wall
Those who found death down there,
An' 'tis the tap tap of tiny picks
Which makes on end stand our 'air.

So we'll leave the 'aunted place
For we won't work where they be,
An' wherever we 'ear their knockin'

We sure will always flee.
For it means whoever 'ears it
Will be the next in line,
For the tap, tap, tap of Knockers Is a last an' awful sign!

Courtesy: Treasure Mountain Home. Park City Revisited. 1969.
By George A. Thompson and Fraser Buck.

Three miners with a mule train at the Alliance Mine.
Image courtesy the Kendall Webb Collection

NOTES

LESSON 6

Teacher Guide

The Power of Steam

Lesson Overview

Students read about historic steam powered mining equipment and perform a related experiment. Students describe how a steam engine works, and discover how such an engine powered a mine hoist, a pump, and a locomotive in Park City.

Time: 90 minutes: 25 minutes talk/demonstration, 45 minutes lab, 20 minutes homework extension

Learning Objectives

Students will be able to:

- Name several machines operated by steam in early Park City.
- Explain what happens when steam is under pressure.
- Draw a diagram explaining how a steam engine works.

Core Curriculum Requirements

Standard 4: Students will understand the relationships among energy, force, and motion.

Objective 3: Investigate the application of forces that act on objects, and the resulting motion.

a. Calculate the mechanical advantage created by a lever.
b. Engineer a device that uses levers or inclined planes to create a mechanical advantage.
c. Engineer a device that uses friction to control the motion of an object.
d. Design and build a complex machine capable of doing a specified task.

Prerequisite:

Review animation of steam engines moving and locomotive wheels turning at http://science.howstuffworks.com/steam.htm

Materials

- Reading - “The Power of Steam”
- Historic photos and diagrams
- Wheel & piston model
- Water & measuring cups
- Thermometers
- Pots of equal size with tight fitting lids that have no holes
- Overhead projector
- Lab activity “The Power of Steam”
- Paper & pencils

Instructional Sequence

1. State objectives and write them on the board.

Ask: After using dynamite to break up the rock at the end of tunnels, how did miners get the rock out of the mine?

Explain: They shoveled it into ore cars which ran along railroad tracks. The miners who shoveled the rock were called muckers.

Ask: How did they get the ore cars up the mine shaft?

Explain: They put the ore cars in a cage, and the hoistman hauled them up using a cable and drum system called a hoist.

Ask: There was no electricity in the 1880s, so what powered the hoist?

Explain: A steam engine. We're going to learn how steam engines work.

Go to http://science.howstuffworks.com/steam.htm. This web page has two animations of steam engines moving and locomotive wheels turning. Review these pages for detailed information before giving your talk.

2. Introduce new vocabulary. See Glossary in the back.

Pressure	Rod	Piston	Boiler
Safety valve	Cage	Steam	Hoist
Boiling point	Locomotive	Suction	Vacuum

3. Give a talk based on the reading "The Power of Steam" to explain how steam engines work.

Copy historic photographs and diagrams onto a transparency, and use them to explain how locomotive steam engines work. Use the classroom wheel and piston model to explain how locomotive wheels turned.

4. Copy, distribute and assign the lab activity "The Power of Steam."

The purpose of this activity is to observe water boil in open and closed pots and record the differences. The entire class observes the experiment together.

5. Debrief the experiment with the following questions.

Q: Does a covered pot of water boil faster than an open pot? Why?
A: Yes, a covered pot of water boils faster than an open pot, because the increasing pressure cannot escape. The pressure inside the pot increases, which in turn increases the speed of the heating process.

Q: Why is steam hotter than liquid water?
A: Water boils at 100°C. With increasing heat even more, the water turns into steam.

Q: How does the heat create steam and pressure?
A: The increasing heat causes the water to evaporate; it turns into steam which is a gas. If the pot is closed, the expanding gas cannot escape, instead the pressure inside the closed pot increases.

Q: How is the pressure cooker similar to a boiler at a mine site?
A: Boilers at mine sites were huge tanks in which water was heated. With increasing heat, pressure and steam built up inside. The force of the steam was used to power different machines. Inside a pressure cooker, the steam is used to cook food.

Bonus Assignment

Students read the History Box "Innovative Technology at the Mines" and visit the Park City Museum to look at one of the buckets from an aerial tramway.

LESSON 6

The Power of Steam

By the time silver was discovered in Park City in 1868, **steam** engine technology was well-known and widely used. Steam engines powered the **hoists** in the mines. Hoists were the big cable and pulley machines that lifted the ore up the mine shaft in **cages** and lowered men down into the mines (Fig. 6.1). They were operated by the hoistman.

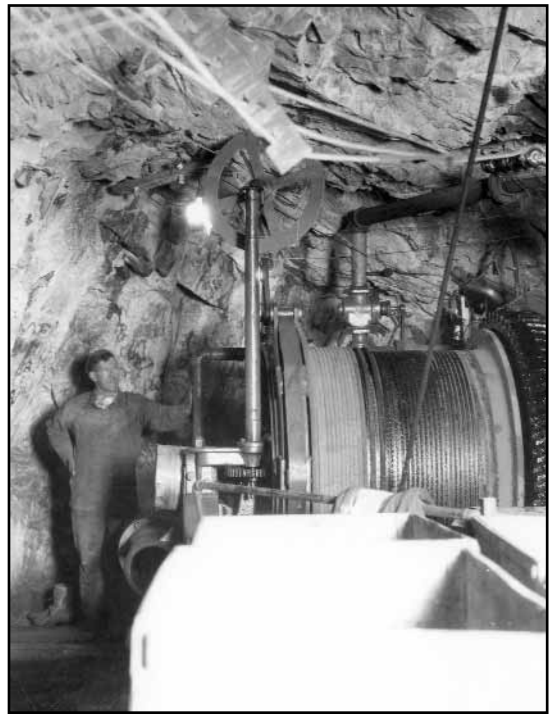


Fig. 6.1 The cable attached to the cage was wound around a huge drum. The steam-powered machinery turned the drum, letting the cable out over a pulley and lowering the cage into the mine shaft. To bring the ore up, the hoistman reversed the turning of the drum.

Image courtesy the Pop Jenks Collection.

How Steam Engines Work

When you boil water in a tea kettle, what makes the tea kettle whistle? Steam. Water boils at 100 °C (212 °F) at sea level. When water boils, the water turns into steam, which is a gas. Upon further heating, the gas in the tea kettle expands and seeks to find an escape route. As the temperature rises, the **pressure** builds up and the steam

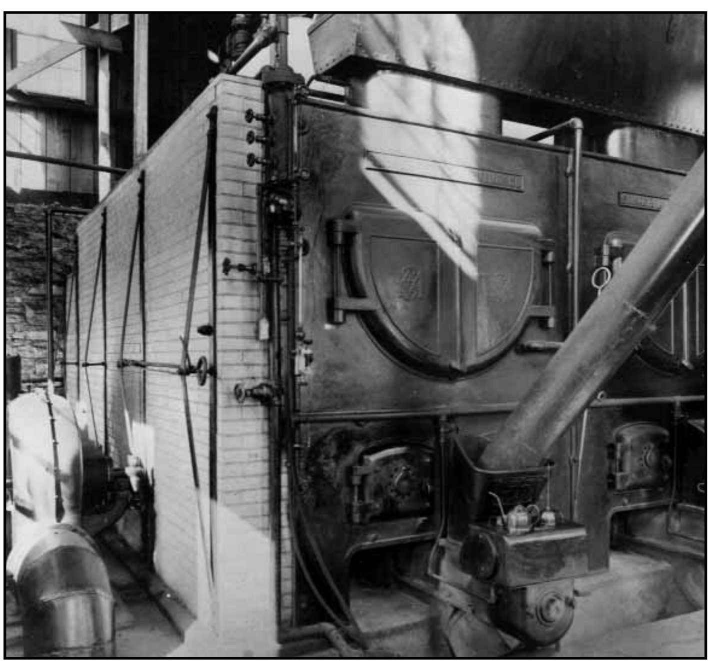


Fig. 6.2 The boiler at the Silver King Mine.

vents rapidly out of a little hole, resulting in a high-pitched whistle.

Similar to tea kettles, the mines in Park City heated water in huge tanks called **boilers** (Fig. 6.2). Miners stoked the fires underneath these tanks with wood or coal. When the water in the tank was heated, the pressure and steam built up inside. Miners who tended the boilers had dangerous jobs. If the pressure became too intense the boiler could blow up, sending scalding hot water through the air.

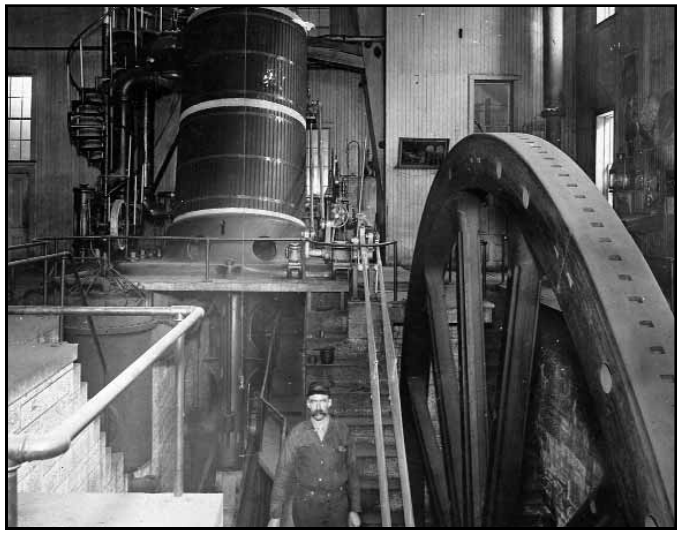


Fig. 6.3 The chamber of the Cornish pump was huge. It could pump 2,560 gallons per minute or 153,600 gallons of water per hour.

From the boiler, the steam went into a chamber. Inside the chamber was a device called a **piston.** The force of the steam moved the piston back and forth. When the piston was tied to a **rod**, it would turn wheels or the drum of a hoist.

Steam engines also powered pumps. When the shafts reached a certain depth in Park City's mountains, water usually flooded the mines. Huge pumps, like the famous Cornish Pump (Fig. 6.3), were powered by steam engines to discharge the water.

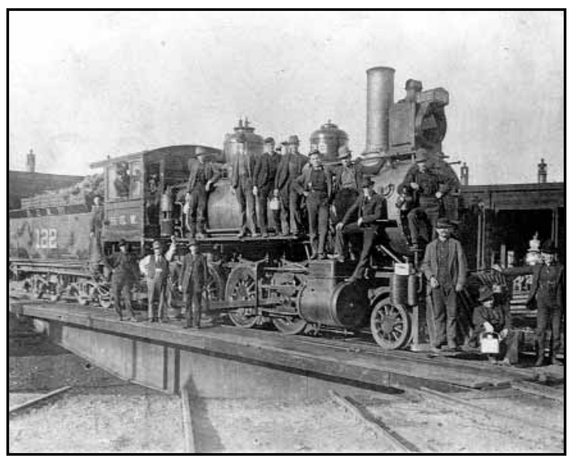


Fig. 6.4 Steam from boilers on the train engine moved a piston from side to side. The piston was tied to rods and wheels which made the train move down the tracks.

By 1890, the Utah Central railroad from Salt Lake City and the Union Pacific railroad from Echo had both completed their spur lines at the bottom of Main Street (Fig. 6.4). Their steam **locomotives** were massive. They hauled tons of silver ore out of Park City and quickly replaced horses and wagons.

How A Steam Engine Works

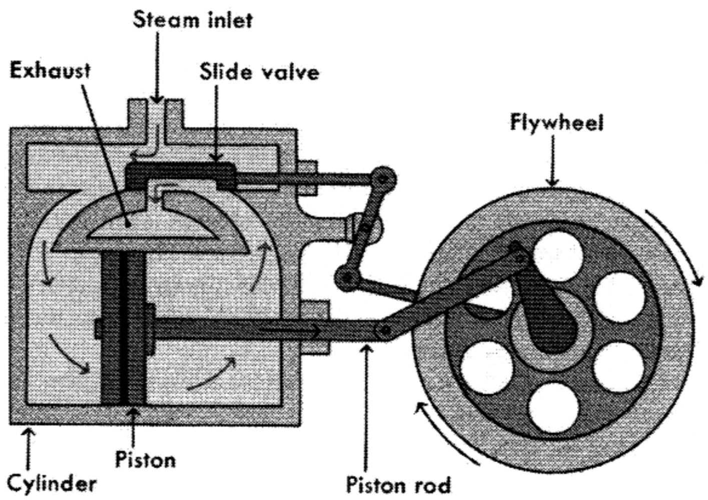


Fig. 6.5

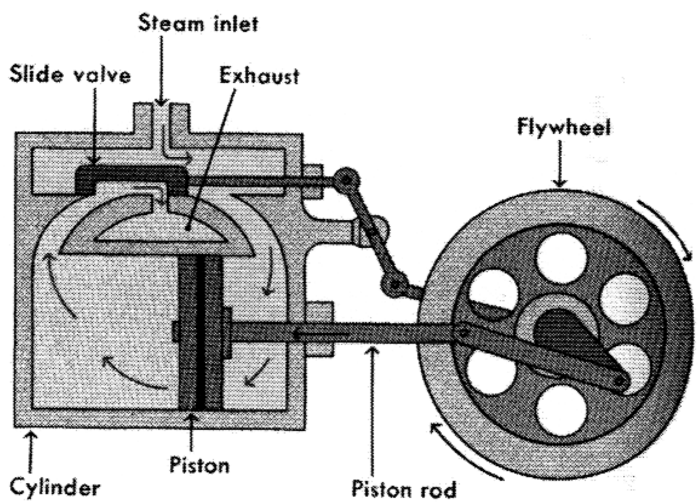


Fig. 6.6

Steam operated the engine by pushing first on one side of the piston and then on the other. A slide valve directs the steam from side to side. In the diagram above, steam enters from the left side of the cylinder and forces the piston to the right. As the piston moves, the piston rod turns the flywheel half a turn (Fig. 6.5).

When the piston reaches the right side of the cylinder, the slide valve moves and directs the steam behind the piston again. The steam forces the piston to the left. The piston rod then pulls the flywheel around to complete one turn. Steam in the left side of the cylinder escapes through the exhaust (Fig. 6.6).

Fig. 6.5 and Fig. 6.6 Steam engine Image courtesy The World Book Encyclopedia

NOTES

Checkpoint

Match the term with its description.

___	1.	Pressure	a. Train engine
___	2.	Piston	b. Releases steam before pressure becomes too great
___	3.	Steam	c. Large tank with a fire under it
___	4.	Safety valve	d. Force
___	5.	Boiling point	e. The machinery that lifts the cage in a mine
___	6.	100° C	f. A plug inside a chamber that moves back and forth
___	7.	Suction	g. A kind of elevator in a mine
___	8.	Rod & piston	h. Makes wheels or a drum turn
___	9.	Boiler	i. Boiling point of water at sea level
___	10.	Cage	j. Temperature at which a liquid boils
___	11.	Hoist	k. Vaporized water
___	12.	Locomotive	l. Creation of a partial vacuum or low pressure
___	13.	Vacuum	m. Area of low pressure or no air

Fill in the Blank

1. When you suck on a straw, you are creating a partial _______________, which the liquid in your drink must fill; that's why the liquid is sucked into your mouth.

2. The piston in a pump must fit tightly in the chamber in order to ___________ the water into the chamber.

3. In a locomotive steam engine, the ___________ moves from side to side.

4. In a hoist, the cable is wound around a drum turned by a __________ and piston.

5. The force of steam called _______________can blow a mine boiler sky high.

LESSON 6

Checkpoint

Answer Guide

Match the term with its description.

Answer	No.	Term	Description
d	1.	Pressure	a. Train engine
f	2.	Piston	b. Releases steam before pressure becomes too great
k	3.	Steam	c. Large tank with a fire under it
b	4.	Safety valve	d. Force
j	5.	Boiling point	e. The machinery that lifts the cage in a mine
i	6.	100° C	f. A plug inside a chamber that moves back and forth.
l	7.	Suction	g. A kind of elevator in a mine
h	8.	Rod & piston	h. Makes wheels or a drum turn
c	9.	Boiler	i. Boiling point of water at sea level
g	10.	Cage	j. Temperature at which a liquid boils
e	11.	Hoist	k. Vaporized water
a	12.	Locomotive	l. Creation of a partial vacuum or low pressure
m	13.	Vacuum	m. Area of low pressure or no air

Fill in the Blank Answers

1. When you suck on a straw, you are creating a partial **vacuum**, which the liquid in your drink must fill; that's why the liquid is sucked into your mouth.

2. The piston in a pump must fit tightly in the chamber in order to **suck** the water into the chamber.

3. In a locomotive steam engine the **piston** moves from side to side.

4. In a hoist, the cable is wound around a drum turned by a **rod** and piston.

5. The force of steam called **pressure** can blow a mine boiler sky high.

LESSON 6

The Power of Steam

Instructions:

Measure two cups of water into two pots.

Close one of the pots with a tight lid.

Place the pots on two different burners, side by side.

Turn the burners on to the same setting - high, and record the exact time when you turned on the heat.

Predict what will happen:

Will the water boil at the same time?

Every 60 seconds, make observations about what you see, and measure the temperature.

Which pot boils first? Why? Which appears to have the most steam? Why?

Make a graph of your findings, with time on the bottom axis and temperature on the left-hand axis.

	Closed Pot	Open Pot
Time when you tuned on the heat		
Predictions		
Observation and Temperature after 60 seconds		
Observation and Temperature after 120 seconds		
Observation and Temperature after 180 seconds		
Observation and Temperature after 240 seconds		
Observation and Temperature after 300 seconds		
Which pot boils first?		
Which pot has the most steam?		

LESSON 6

LAB ACTIVITY

ANSWER GUIDE

The Power of Steam

Instructions:

Measure two cups of water into two pots.

Close one of the pots with a tight lid.

Place the pots on two different burners, side by side.

Turn the burners on to the same setting - high, and record the exact time when you turned on the heat.

Predict what will happen:
Will the water boil at the same time?
No, the water inside the closed pot will boil first.

Every 60 seconds, make observations about what you see, and measure the temperature.

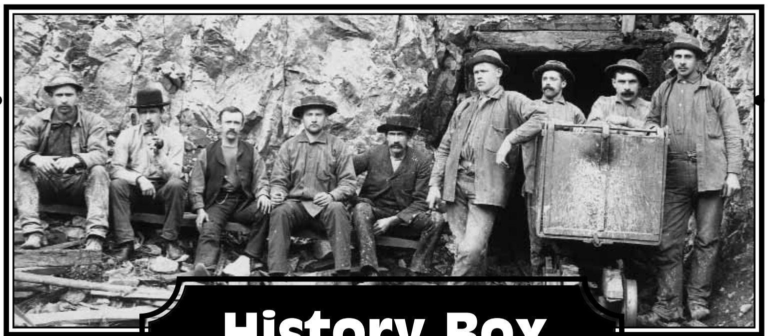
Which pot boils first? Why?
The covered pot boils faster, because the increasing pressure cannot escape. The pressure inside the pot increases, which in turn increases the speed of the heating process.

Which appears to have the most steam? Why?
The open pot produces the most steam, because the increasing heat causes the water to evaporate; it turns into steam.

Make a graph of your findings, with time on the bottom axis and temperature on the left-hand axis.

	Closed Pot	Open Pot
Time when you tuned on the heat		
Predictions	The water in this pot will boil first.	The water in this pot will boil second.
Observation and Temperature after 60 seconds	a s	t e m
Observation and Temperature after 120 seconds	t i m e	p e r a t
Observation and Temperature after 180 seconds	i n	u r e
Observation and Temperature after 240 seconds	c r e a	w i l l
Observation and Temperature after 300 seconds	s e s	r i
Which pot boils first?	The water in this pot boils first.	s e
Which pot has the most steam?		This pot has the most steam.

LESSON 6

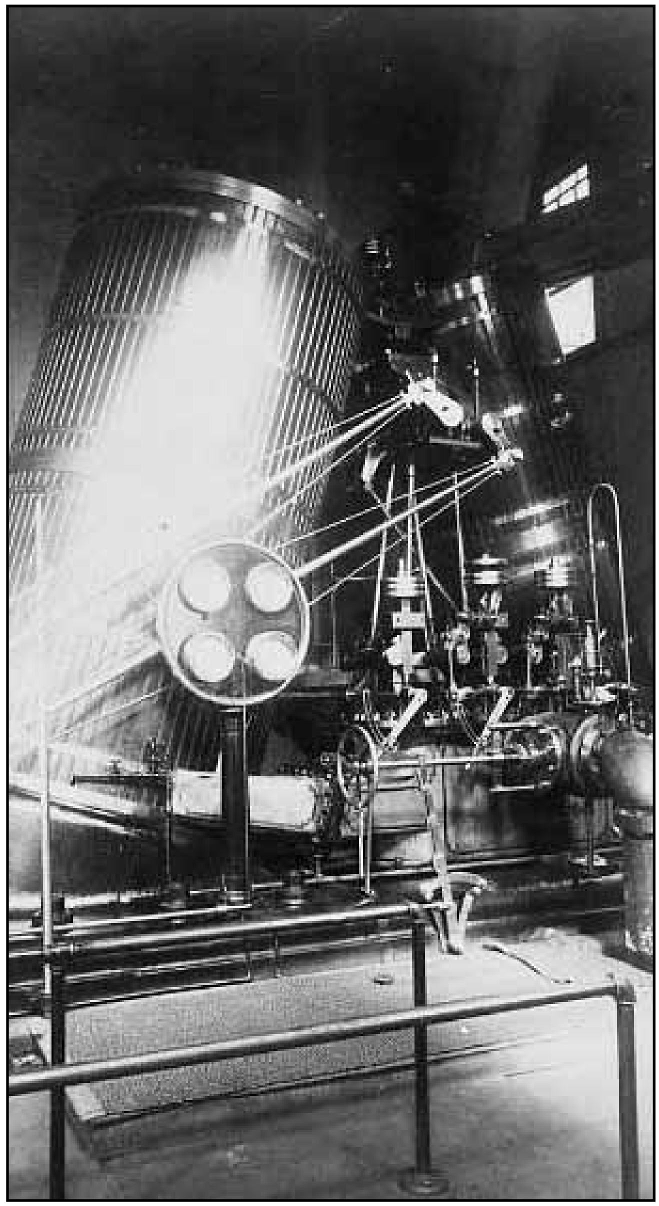


History Box

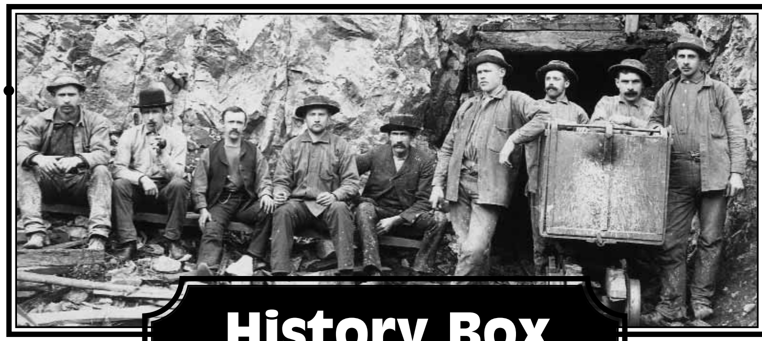
Innovative Technology in Mining

As the Ontario Mine shafts were sunk to deeper depths, miners encountered heavy flows of underground water. Initially a drain tunnel was dug, but it only allowed an additional few hundred feet of shaft, not enough to reach the richest ore. Mine owner George Hearst and his colleagues found inspiration in a group of men from Cornwall, England, who had designed a giant pump to empty water from the diamond mines of South Africa. Park City's Cornish Pump was modeled after this pump and was installed in the Ontario Mine in 1881.

The Cornish Pump was powered by a steam engine located on the surface, while the pump itself was located at the shaft's 1,000-foot level. The 1,060-foot long connecting rod was attached to the engine which was connected to the 30-foot diameter flywheel. As the wheel turned, the pump's two-inch pistons pumped water from the 1,000-foot level to the



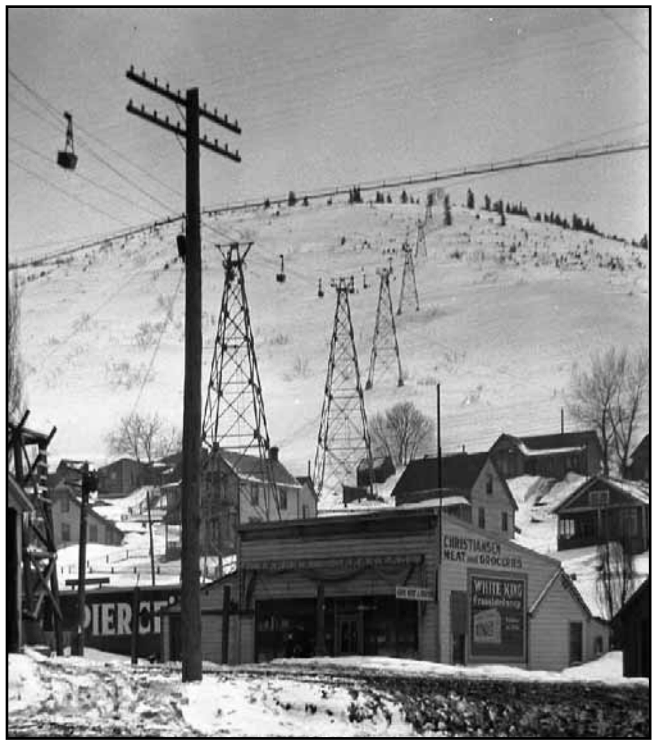
The Cornish Pump at the Ontario Mine.



History Box

600-foot level drain tunnel. The pump removed about 3.5 million gallons of water a day, allowing the miners to venture deeper into the ore-filled mountains.

The same way the Cornish Pump improved mining at the Ontario, the Silver King Mining Company added a technology that would revolutionize their mining. In 1901, the Silver King built an aerial tramway. The aerial tramway consisted of 40 steel towers and 80 buckets that traveled up and down the mountain like a ski lift, bringing ore to the city and taking coal and supplies back up to the mine. The tramway, whose towers are still visible next to the Town Lift at Park City Mountain Resort, not only allowed ore to be transported year-round, but it reduced hauling costs from $1.50 per ton for wagons to 22¢ per ton in the buckets.



The Aerial Tramway built by the Silver King Mining Company.
Image courtesy the Himes-Buck Digital Collection

LESSON 7

Teacher Guide

Milling It Over

Lesson Overview

Students develop hypotheses about the milling processes taking place inside 19th century mill buildings. Students will use the stamp battery model to figure out how ore is crushed.

Time: 90 minutes: 30 minutes group work, 10 minutes lecture,
40 minutes model assembly, 10 minutes stamp battery exercise

Learning Objectives

Students will be able to:

- Develop hypotheses about how valuable minerals were separated from ore.
- Design and build a model which separates peanuts from their shells, simulating the ore recovery process.

Core Curriculum Requirements

Standard 4: Students will understand the relationships among energy, force, and motion.
Objective 2: Examine the force exerted on objects by gravity.
e. Engineer a machine that uses gravity to accomplish a task.
Objective 3: Investigate the application of forces that act on objects, and the resulting motion.
a. Calculate the mechanical advantage created by a lever.
b. Engineer a device that uses levers or inclined planes to create a mechanical advantage.
c. Engineer a device that uses friction to control the motion of an object.
d. Design and build a complex machine capable of doing a specified task.

Prerequisite: All prior lessons

Materials

- Reading - “How Were Valuable Minerals Recovered from Ore?”
- Paper & pencils
- Historic photographs from reading
- Classroom Exercise “What Went On in These Buildings?”
- Diagram of mill process
- Stamp battery model
- Peanuts with shells
- Overhead projector

Instructional Sequence

1. State objectives and write them on the board.

Ask: How many of you ski at Park City Mountain Resort? Ask for a show of hands.
Display photo of Silver King Mill. How many of you have ever noticed the huge building downhill from the base of the Bonanza Chairlift? How many of you know what went on in that building?

Explain: Today you'll learn what went on in there. We'll talk about how valuable minerals were removed from ore.

2. Introduce new vocabulary. See Glossary in the back.

Grizzly	Milling process	Jaw crushers	Tailings
Stamp mill	Smelter	Concentrating table	Hydrophobic
Cam	Tappet		

3. Copy, distribute and assign the reading "How Were Valuable Minerals Recovered from Ore?"

The reading can be done with the entire class or in groups.
Go through the classroom exercise "What went on in these buildings?" with students.

4. To conclude, display the diagram of a 19th century mill on the overhead projector, and explain the mill process. Validate the following learning points:

The mill was always built on the side of a hill, because it used gravity to channel and process the rock.

Steam powered machines simulated the weathering processes of nature. For example, erosion, which is the wearing away of lighter materials (sand, quartz, etc.) on a sloped area.

A process similar to gold panning was used to separate pulverized minerals from pulverized waste rock. Valuable minerals are heavier than waste rock and will drop to the bottom.

At the mills the ore was crushed into tiny particles and processed to concentrate the valuable minerals which were then shipped to the smelters in Salt Lake City.

5. Run the stamp battery lab activity.

Groups will have 30 minutes to assemble a model of a stamp.

Distribute a set of model building components and nuts to each group.

Coach each group by pointing out the principles of force and motion in play (gravity, lever, mass/weight).

6. Debrief the stamp battery exercise.

Have each group demonstrate their models, answering the following questions in their presentation:

What did you try first?
Did it work? If not, how did you fix the problem?
Use the Checkpoint sheet to emphasize the learning points.

Bonus Assignment

Students read the History Box "Mills Saved Money" and conduct more research at the History Library of the Park City Museum. Students do a report in class.

LESSON 7

How Were Valuable Minerals Recovered from Ore?

Ore in the Park City Mining District contained silver, lead, zinc, and small amounts of copper and gold. Silver was the most sought after metal, and therefore the mines of Park City are simply known as silver mines. Lead was present as the mineral galena or lead sulfide (PbS). Silver was closely associated with galena but also with tetrahedrite (copper iron sulfides containing antimony $(Cu, Fe)_{12}\ Sb_4S_{13}$). Sphalerite or zinc sulfide (ZnS) was also present. The average Park City Mining District ore contained 166 pounds of lead, 90 pounds of zinc and about one troy pound of silver. The ore mining process often produced significant waste rock along with the valuable minerals containing the lead, zinc and silver. **Milling** and concentrating is the process used to separate as completely as possible the valuable minerals from the waste rock in the ore.

Fig. 7.1 Two miners stand next to a full ore car in front of a mine tunnel entrance.

What are mills and what did they look like?

Mills were the buildings that contained the equipment used to separate the valuable minerals from the waste rock (Figure 7.2). Generally this was done as close as possible to the mines so the ore did not have to be transported very far. By concentrating the valuable minerals near the mine, only a small amount of material had to be transported to the **smelter** for recovery of the metals. Transporting ore was expensive for the mining companies and they attempted to eliminate or at least minimize this cost. Smelters were located some distance from the mining operations, with the closest ones in the Salt Lake City area.

The first mills built in the Park City Mining District were constructed in the 1870's. The early mills were quite simple by today's standards but used many of the same basic principles as today's more complex mills. These early mill structures were very distinctive and constructed along the hillsides near the mines to utilize gravity to facilitate the flow of material through the processing equipment.

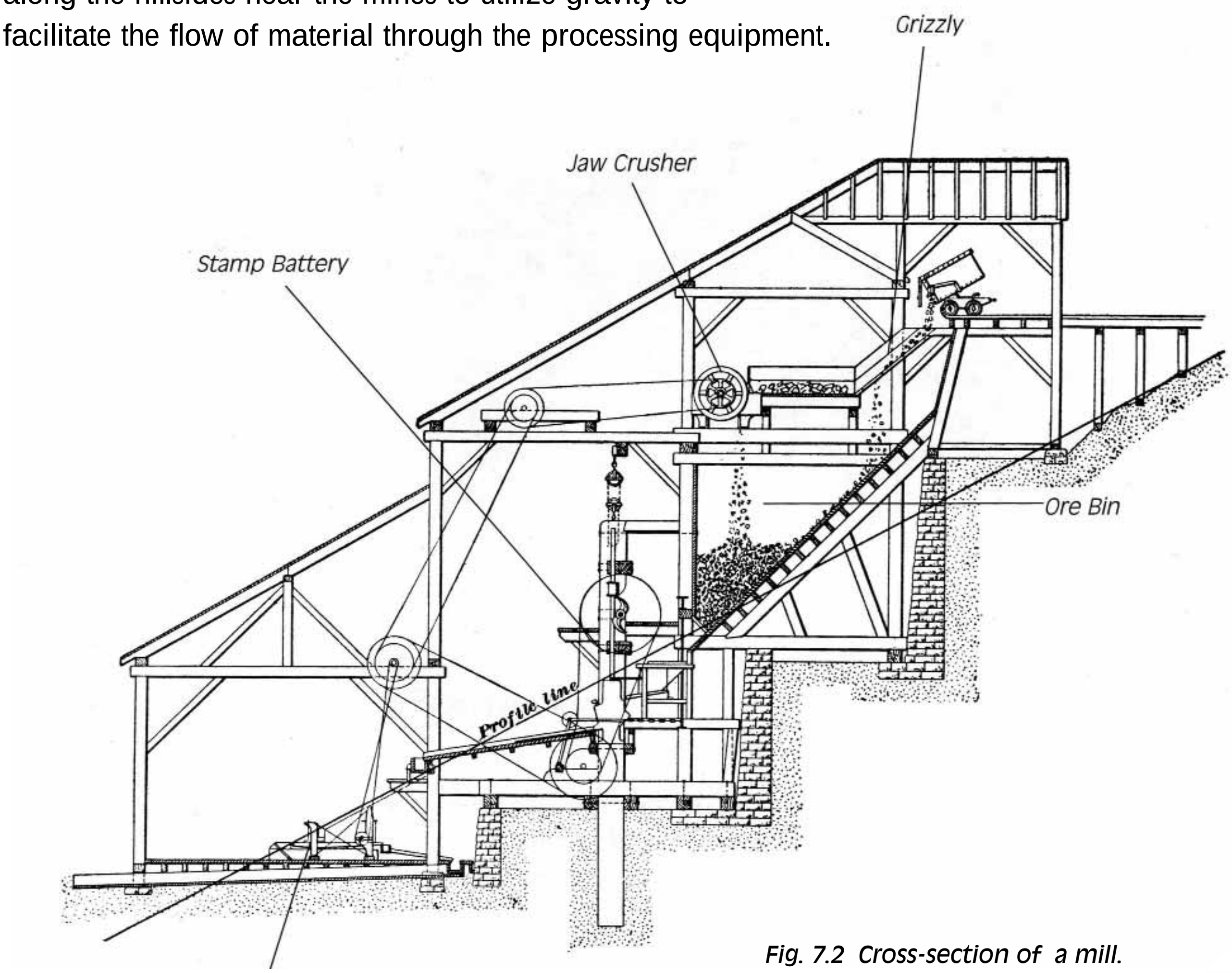
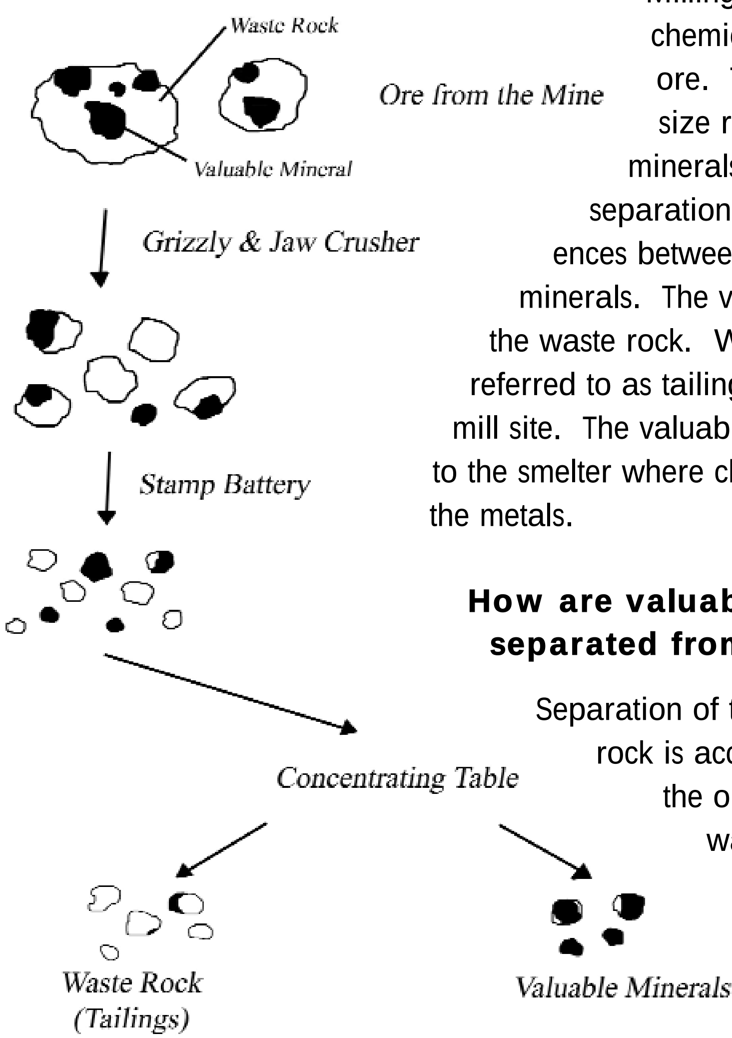


Fig. 7.2 Cross-section of a mill.

Image courtesy The Mining Camps Speak.

How did the early mills in the Park City Mining District work?



Milling is a physical process and does not chemically alter the minerals present in the ore. The concentrating process involves size reduction to liberate the valuable minerals from the waste rock, followed by separation based on the specific gravity differences between the waste rock and the valuable minerals. The valuable minerals are heavier than the waste rock. Waste rock from the milling process is referred to as tailings and is usually disposed of at the mill site. The valuable mineral concentrate is transported to the smelter where chemical changes eventually recover the metals.

How are valuable minerals separated from the waste rock?

Separation of the valuable minerals from the waste rock is accomplished by reducing the size of the ore until the valuable minerals and waste rock are distinct from each other. (Figure 7.3).

Fig. 7.3 The process of separating valuable minerals and waste rock as the ore travels through the mill.

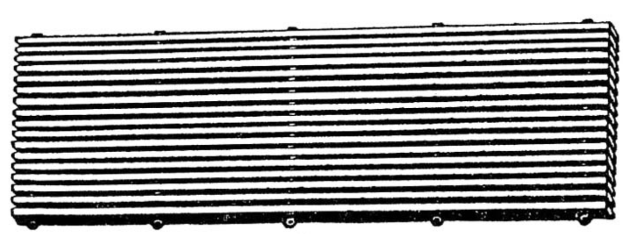


Fig. 7.4 The grizzly screen lets ore that is less than 2 inches bypass the jaw crusher.
Image courtesy The Mining Camps Speak.

Crushing Operations

Typically, ore entering an early Park City mill was as large as six to ten inches and passed over a **grizzly** before entering a **jaw crusher**. A grizzly is simply a series of metal bars placed several inches apart (Figure 7.4).

Smaller ore passes through the grizzly and bypasses the crusher. Jaw crushers (Figure 7.5) take large pieces of ore and reduce them in size to something less than two inches. Jaw crushers have a hinged plate that moves back and forth with great force, and only material of a small size can exit the crusher. However, ore of this size is still too large and further size reduction is required to liberate the valuable minerals.

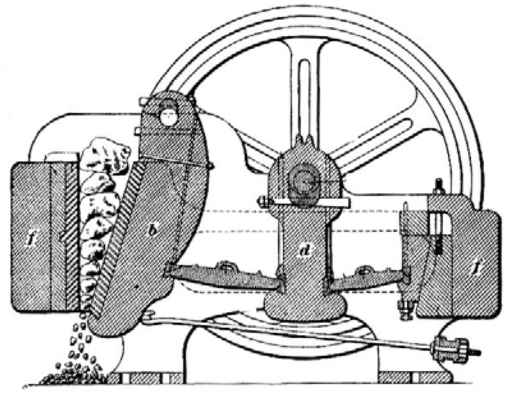


Fig. 7.5 The jaw crusher reduces ore from 10 inches to less than 2 inches.
Image courtesy The Mining Camps Speak.

Stamp Mill Operation

The ore from the crusher enters a surge bin and is fed into the **stamp mills** (Figure 7.6). Stamp mills take the two inch crushed ore and further reduce it in size to less than $^1/_{16}$ inch. At this size there are distinct differences between the various particles. Some are all waste rock, some are valuable minerals, but some are still a combination of rock and valuable mineral. The stamp mills liberate minerals from the ore. Since the valuable minerals are heavier than the host rock, they can be separated based on these specific gravity differences.

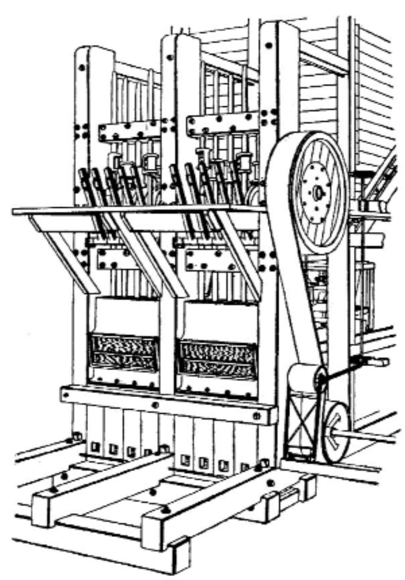


Fig. 7.6 The stamp battery reduces ore from 2 inches to less than $^1/_{16}$ inch.
Image courtesy The Mining Camps Speak.

The stamp mill is a mechanical form of the ancient mortar and pestle. The mills in Park City used gravity stamps. The mortar is attached to a massive concrete foundation. The pestle is attached to a stem and lifted by means of a **cam** shaft working on a **tappet**. Ore is crushed when the pestle free falls. Water is added with the feed from the surge bin to aid discharge when the ore is broken small enough to pass through a screen and exit the stamp mill. A stamp battery typically contains five pestles. The pestle is lifted 6 to 8 inches at a rate of 100 drops per minute, and weighs 1,250 to 1,500 pounds. The valuable minerals and waste rock are now reduced in size to the point where they are distinctly different.

Concentrating Tables

Separation of the valuable minerals from the waste rock is accomplished based on specific gravity differences. In the early Park City Mining District, gravity separation occurred on **concentrating tables** (Fig. 7.7). Concentrating tables work like gold pans. If particles of valuable minerals and waste rock are continually agitated in a pan of water, the heavier valuable minerals will accelerate faster and fall further than the lighter waste rock and collect at the bottom. This is a result of the difference between the specific gravity of the valuable minerals and the water being greater than the specific gravity difference of the waste rock and the water. Particle size also has something to do with the separation.

Tables are normally rectangular and have riffles parallel to the long side. They are slightly sloped and shaken with a differential movement in the direction of the long axis and washed by a stream of water. As the feed flows down the table, the combination of forces stratifies the bed behind the riffles. The wash water carries the waste rock particles over the riffles to the bottom of the table to be collected as **tailings**, while the valuable minerals at the bottom of the bed are moved parallel to the riffles to the end of the table to be collected as concentrate.

The separation process based on specific gravity is not perfect. There is always some waste rock with the valuable minerals and some traces of valuable minerals with the waste rock or tailings. The mill tailings are stacked near the mill site, and the concentrate is sent to the smelter for recovery of the metals.

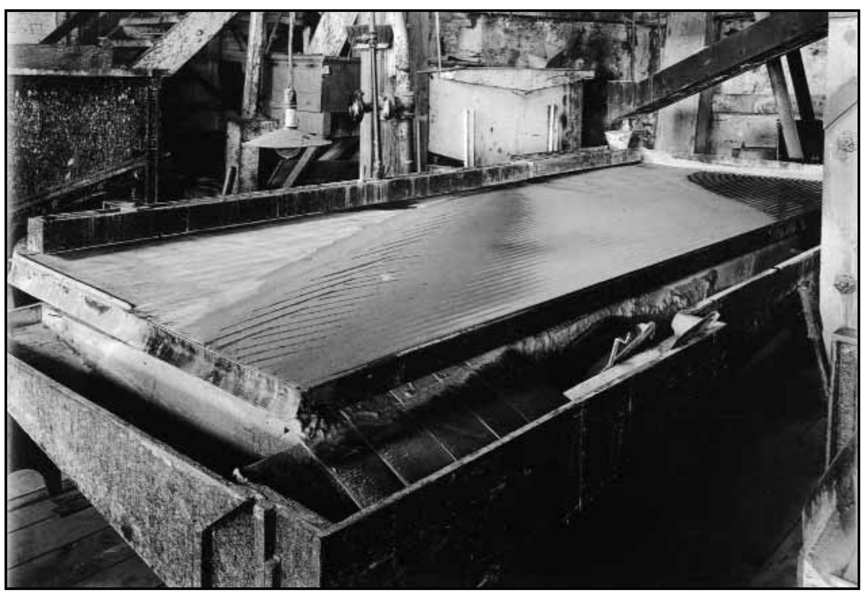


Fig. 7.7 A concentrating table at a Park City mill.

Image courtesy The Pop Jenks Collection

How have milling methods changed over time?

Milling continually changed as new technology became available to make the mills more efficient. These changes included improvements which increased the amount of valuable minerals recovered, produced a higher percentage of valuable minerals in the concentrate, or lowered costs of the milling process. Ore was ground to finer sizes to liberate very fine particles of valuable minerals. This was made possible by the use of ball mills which replaced the stamp mills. Also, in the 1920s, froth flotation cells replaced the concentrating tables. Froth flotation cells exploited the difference in surface properties of the valuable minerals and the waste rock. The valuable minerals were **hydrophobic** and could be removed from the waste rock by introducing fine bubbles into a dilute solution of water and ore. The valuable minerals would "float" to the surface attached to the bubbles and be skimmed off the top. Oil and various chemicals were added to the slurry to make the bubbles stable and to improve recovery of the valuable minerals. Depending on the chemicals used, different minerals could even be separated from each other. This produced several concentrates, each rich in a different valuable mineral. Modern milling operations are very sophisticated. Computer controlled technology is used to monitor operations, and state of the art environmental equipment and procedures protect air and water quality.

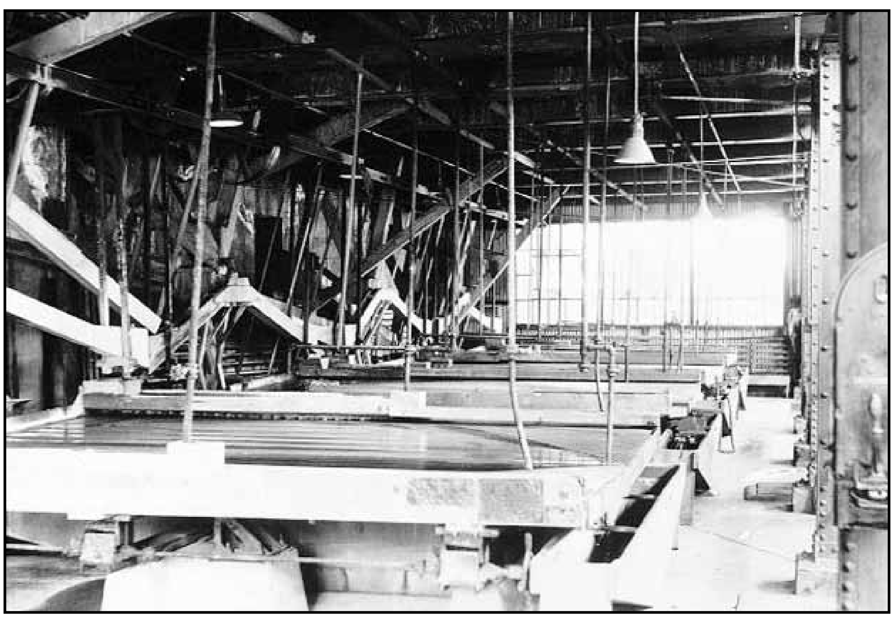
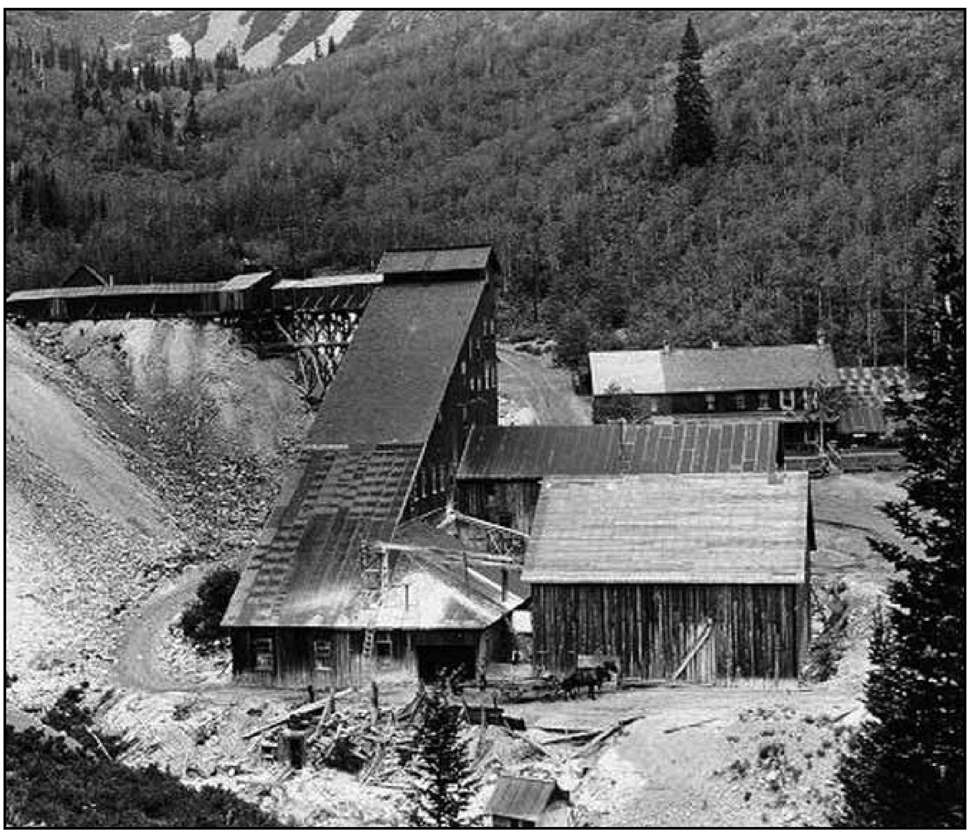


Fig. 7.8 Concentrating tables inside a Park City mill.

Image courtesy The Pop Jenks Collection

7.9 The Union Concentrator in Empire Canyon

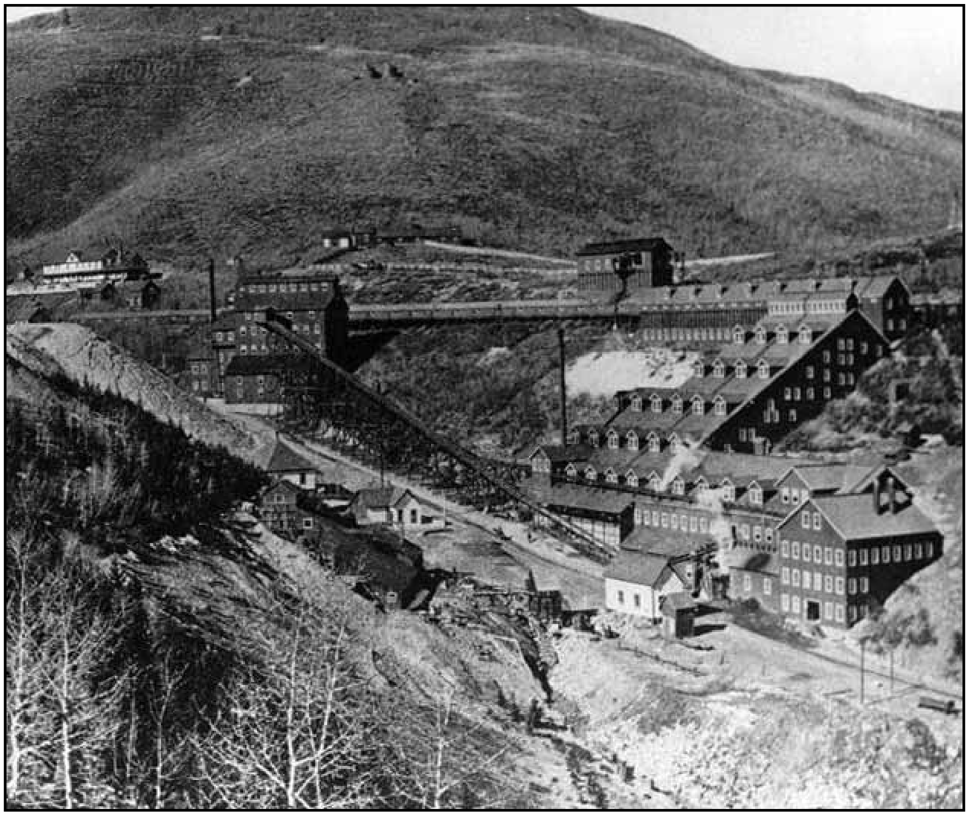
Image courtesy the Himes-Buck Digital Collection.



7.10 The Kearns-Keith Mill in Walker-Webster Gulch.

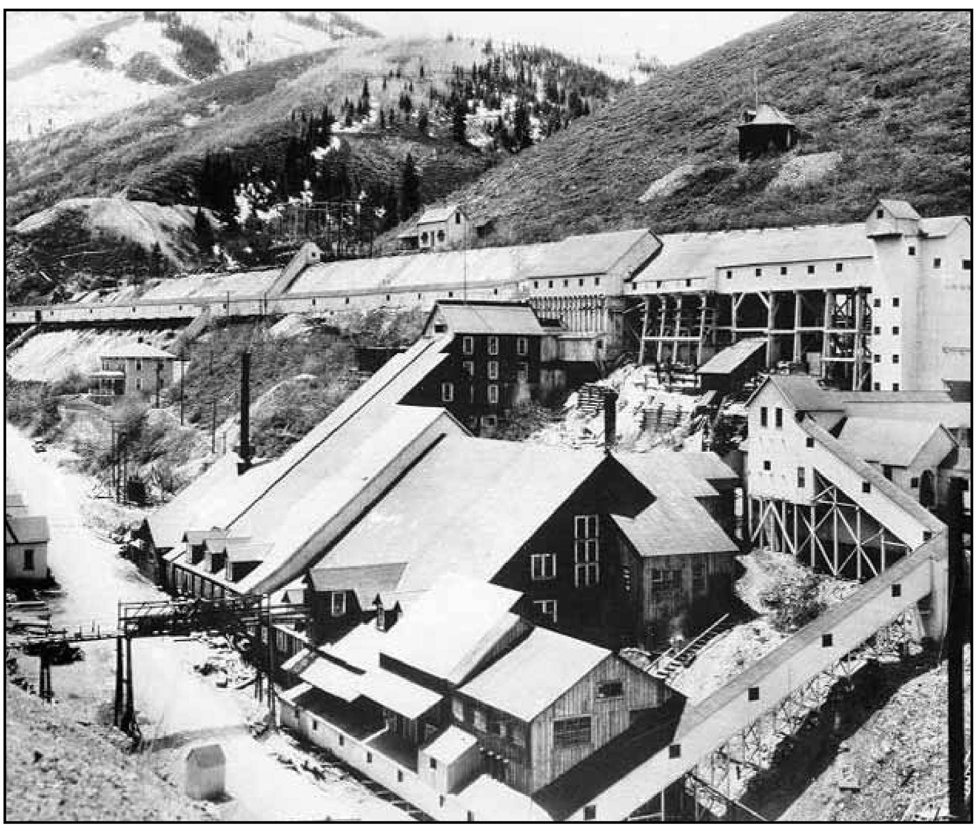
Image courtesy the Pop Jenks Collection.

LESSON 7



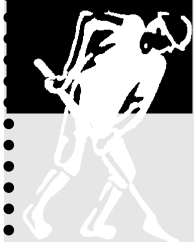
7.11 The original Silver King Mill in Woodside Gulch.

Image courtesy the Himes-Buck Digital Collection.



7.12 The Daly Judge Mill in Empire Canyon

Checkpoint



1. **Q:** **What happened inside Park City's mills? Did the ore undergo a physical change or a chemical change?**

A: ____

____

____

____

2. **Q:** **What were the two most important principles used to concentrate the minerals which contain the valuable metals?**

A: ____

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3. **Q:** **Why was the concentration of the valuable minerals so important?**

A: ____

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4. **Q:** **By the end of the mill process was pure silver, pure lead or pure zinc produced?**

A: ____

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____

____

5. **Q:** **What kind of change does it take to recover the valuable metal from the mill concentrates – a physical change or a chemical change?**

A: ____

____

____

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Checkpoint

Answer Guide

1. **Q: What happened inside Park City's mills? Did the ore undergo a physical change or a chemical change?**
   A: Physical change. The ore is crushed into particles. Just as you learned when you panned for gold, the lighter material will wash away, and the heavier, silver-bearing minerals will be left behind. In the same way, the concentrating tables separated the valuable minerals by washing the lighter quartz, sand and other waste rock away.

2. **Q: What were the two most important principles used to concentrate the minerals which contain the valuable metals?**
   A: 1. Size reduction to liberate the minerals
   2. Differences in specific gravity of the valuable minerals and waste rock.

3. **Q: Why was the concentration of the valuable minerals so important?**
   A: It prepared them for the smelting process and reduced the amount of material to be transported to smelters.

4. **Q: Was pure silver, pure lead or pure zinc produced by the end of the milling process?**
   A: No, the silver, lead and zinc were still present as the sulfide minerals as they were originally in the ground.

5. **Q: What kind of change does it take to recover the valuable metal from the mill concentrates – a physical change or a chemical change?**
   A: Crushing and concentrating involved physical changes. The valuable minerals were crushed to a smaller size and separated from worthless rock, but they were still the same chemical compounds as they were before.

   Getting pure metal required a chemical change.

   This process was called smelting, which was not done in Park City in the late 1800s. The mills in Park City sent the concentrated ore or concentrates to smelters in Salt Lake City by train.

CLASSROOM EXERCISE

What Went on in These Buildings?

1. **Examine the photographs of various Park City mills. Why do you think these mills were built on the sides of the hills? How did gravity play a role in what went on inside?**

---

2. **Think back to your lesson on placer deposits and how they were formed. How did mining engineers simulate the action of weather, erosion, and friction to recover the valuable minerals from ore?**

---

3. **Recall your experiment with gold panning. How might you use that knowledge to separate valuable minerals from waste rock?**

CLASSROOM EXERCISE

ANSWER GUIDE

What Went on in These Buildings?

1. Examine the photographs of various Park City mills. Why do you think these mills were built on the sides of the hills? How did gravity play a role in what went on inside?

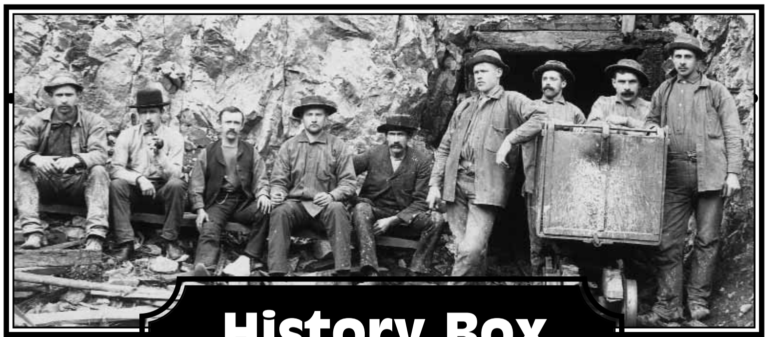
Gravity facilitated the flow of material through the processing equipment.

2. Think back to your lesson on placer deposits and how they were formed. How did mining engineers simulate the action of weather, erosion, and friction to recover the valuable minerals from ore?

Mining engineers designed a concentrating process which reduced the size of the ore. This lead to the liberation of the valuable minerals from the waste rock, which was done with the help of a "grizzly," a "jaw crusher," and a stamp mill.

3. Recall your experiment with gold panning. How might you use that knowledge to separate valuable minerals from waste rock?

If particles of valuable minerals and waste rock are continuously agitated in a pan of water, the heavier valuable minerals will accelerate faster and fall further than the lighter waste rock and collect at the bottom.



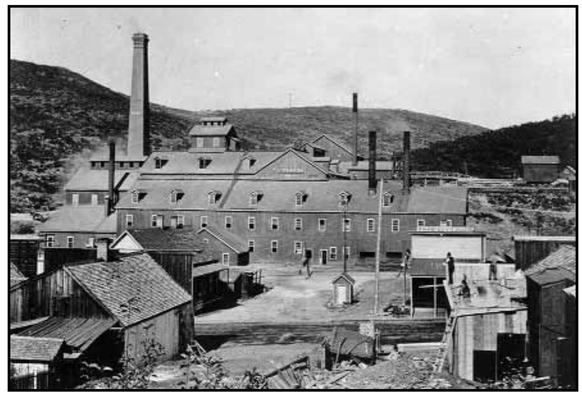
History Box

Mills Saved Money

By 1902, at least a dozen mills had been built in Park City. They created tons of concentrates that were shipped by train to various smelters in the Salt Lake area and elsewhere. Why were mills so important? Why did so many mines erect their own concentrators at such great expense?

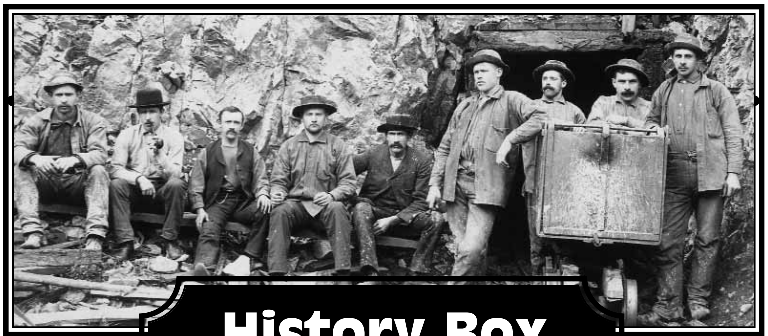
Simple economics. The concentrates contained the valuable minerals. They weighed a fraction of the ore that came straight out of the mines. So it cost far less to transport the concentrates. The savings in transportation costs made up for the cost of building and operating the mills. Negative consequences were that the noise all over Park City was deafening, and the smoke from all the mill steam boilers spread yellow haze over the city.

The first mill in Park City was built in 1874. It was called the Marsac Mill and was located down the hill from the present day Marsac building,



The Marsac Mill in Park City.
Image courtesy the Kendall Webb Collection

Inside the Marsac Mill.



History Box

about where the Transit Center stands today. Its 20 stamps crushed the ore from the Flagstaff Mine and later the Ontario Mine. In 1875, the McHenry Mill opened to service the McHenry Mine and the Ontario Mine. By 1877, the Ontario Mill was constructed with 40 stamps to process the ore from the Ontario Mine.

Here are the names of other Park City mills:

Comstock Mill

Crescent Mill

Daly-Judge Mill

Daly-West Mill

Kearns-Keith Mill

Mayflower Mill

Park City Metals Co. Zinc Mill

Silver King Mill

Union Mill

Union Concentrator

The Silver King Mill still stands today at Park City Mountain Resort. You can see the mill through the woods when you ski off the Payday lift to the Bonanza lift. The Silver King shaft house is at the base of the Bonanza chair, and the mill is down the hill in an out-of-bounds area.

The Silver King Mill Building still stands today.

LESSON 8

Teacher Guide

Do We Have Silver Yet?

Lesson Overview

Students learn which chemical reactions took place in smelters to produce pure metal. Students recognize the difference between physical and chemical changes by using critical thinking skills and writing chemical equations.

Time: 45 minutes

Learning Objectives

Students will be able to:

- Recognize the difference between a physical change process and a chemical change process.
- Write chemical equations.
- State why heat accelerates the chemical reaction in a blast furnace.
- Outline how pure metal is obtained from ore.

Core Curriculum Requirements

Standard 1: Students will understand the nature of changes in matter.

Objective 4: Identify the observable features of chemical reactions.

a. Identify the reactants and products in a given chemical change and describe the presence of the same atoms in both the reactants and products.
c. Demonstrate that mass is conserved in a chemical reaction.
d. Experiment with variables affecting the relative rates of chemical changes.
e. Research and report on how engineers have applied principles of chemistry to an application encountered in daily life.

Prerequisite: All prior lessons

Materials

- Reading - “Do We Have Silver Yet?”
- Overhead projector
- Paper & pencils

Instructional Sequence

1. State objectives and write them on the board.

Explain: You have learned how minerals were mined here in Park City. Today, we will discuss the final step in mining, necessary to produce pure metals. We will learn how the concentrates were shipped to smelters in Salt Lake City and elsewhere. We will also talk about the chemical process which produces the pure silver product.

Go to http://www.bbc.co.uk/history/british/victorians/launch_ani_blast_furnace.shtml This web page has an animation of a blast funace. Review the page for detailed background information before giving your talk.

2. Introduce new vocabulary. See Glossary in the back.

Sinter
Blast furnace
Tender
Chemical change
Law of conservation

3. Give a talk based on the reading "Do We Have Silver Yet?"

Copy, distribute and assign the reading in class or for homework.
Students use Checkpoint sheet.

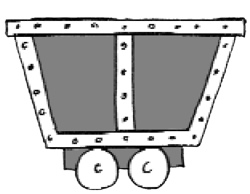
4. Debrief by reviewing the answers to the Checkpoint exercise.

Bonus Assignment

Students research the following topics on www.wikipedia.org:

- Smelting
- Blast furnace
- Combustion
- Extractive Metallurgy

Or students use the History Box "Railroads Made Mining Successful" to do a report on railroads in Park City.



LESSON 8

Do We Have Silver Yet?

Silver ore was crushed and the valuable minerals were extracted in the Park City mills. But after all that work, we still didn't have pure metal. The valuable minerals were pulverized, but they were still the same chemical compounds – galena (PbS) and tetrahedrite ($(Cu,Fe)_{12}Sb_4S_{13}$), which both contain silver, and sphalerite (ZnS). Pure metal was what people wanted, so one more step had to be taken to produce the final products, lead, zinc, and silver.

The final step was called smelting. Park City never had any large-scale smelters. The mills in Park City sent the concentrates to big processing plants, called smelters, in the Salt Lake City area and elsewhere (Fig. 8.1 & 8.2). Smelters were a series of huge furnaces. Different chemical reactions inside these furnaces produced pure metal.

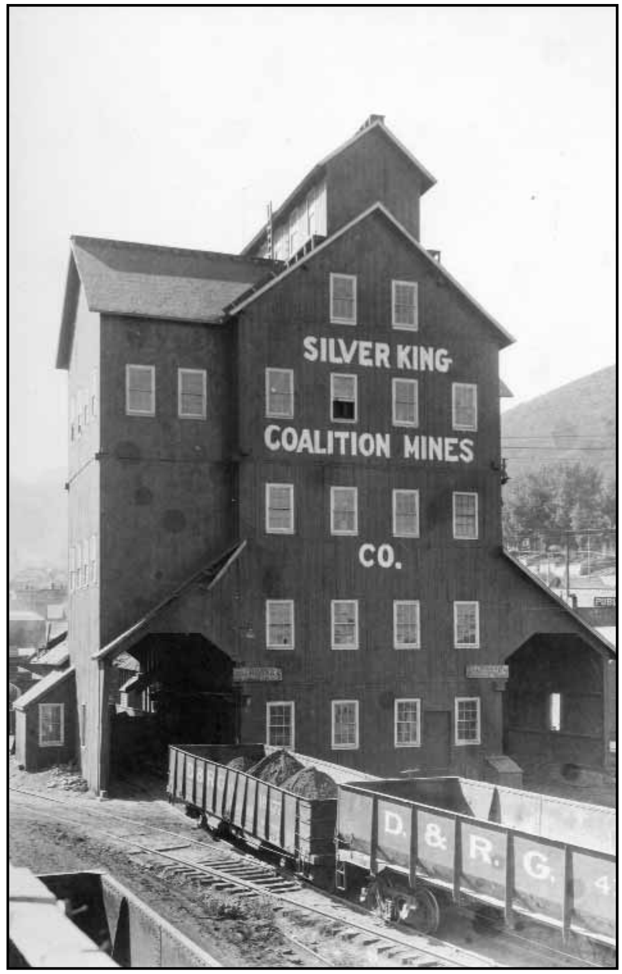


Fig. 8.1 From the Silver King Coalition Building the Silver King shipped their concentrates by train to smelters in Murray.
Image courtesy the Pop Jenks Collection.

Fig. 8.2 The Germania Smelter in Murray, Utah, 1896.
Image courtesy the Utah State Historical Society.

The Smelting Process

Consider this chemical equation. What is happening?

$2PbS + 3O_2 = 2PbO + 2SO_2(g)$

Lead sulfide is combined with oxygen. This chemical reaction yields lead with one oxygen atom or lead oxide (a solid) and sulfur with two oxygen atoms or sulfuric dioxide (a gas). The lead is oxidized.

In the smelter, this chemical reaction occurs in a roasting machine where the rate of the reaction is increased through flash heating.

In addition, carbon (C) is also mixed with the concentrates. The heat fuses the lead into a hard, cake-like substance called **sinter**.

The next step involves the use of **blast furnaces** (Fig. 8.3). Blast furnaces get their name from the blast of oxygen blown into the bottom of the furnace, which controls the reactions in the furnace.

The heat in a blast furnace is fierce. Temperatures at the base of the furnace are 1500 ºC -- high enough to melt metals and waste rock!

Tons of sinter and additional carbon are dumped into the huge blast furnace with other materials. Complex chemical reactions occur inside.

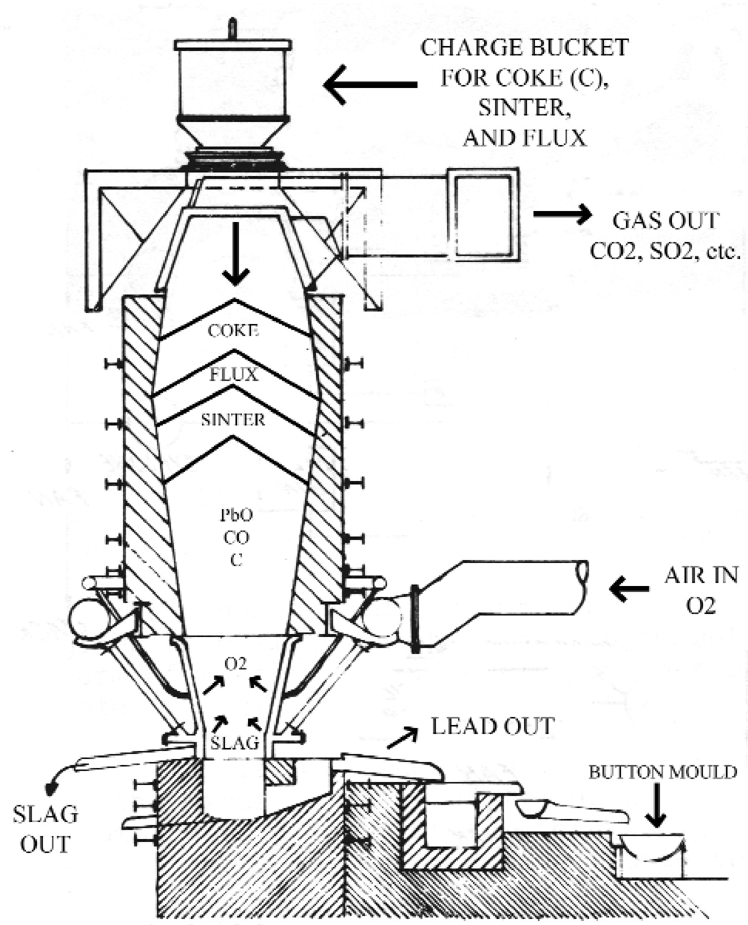


Fig. 8.3 A lead blast furnace.

Here are the most important reactions:

$C + O_2 = CO_2(g)$

As the carbon burns, heat is produced, thus increasing the temperature of the material in the furnace and the rate of chemical reactions. Carbon plus oxygen give off carbon dioxide (CO_2).

$PbO + C = Pb + CO(g)$

At high temperatures and controlled conditions, the carbon reacts with the lead oxide in the sinter. Pure lead is created, along with carbon monoxide (CO), a gas.

$2CO + O_2 = 2CO_2(g)$

The carbon monoxide generates additional heat as it burns and is converted to carbon dioxide.

The 1500 ^{o} C temperature at the bottom of the blast furnace melts the metals which sink to the bottom. Waste rock forms a molten layer above the molten metals.

On average, out of a ton of ore from Park City's mines, the smelters produced only 166 pounds of lead, which was a lot compared to the amount of zinc and silver produced. A typical ton of ore produced only 90 pounds of zinc and about one troy pound of silver (Fig. 8.4).

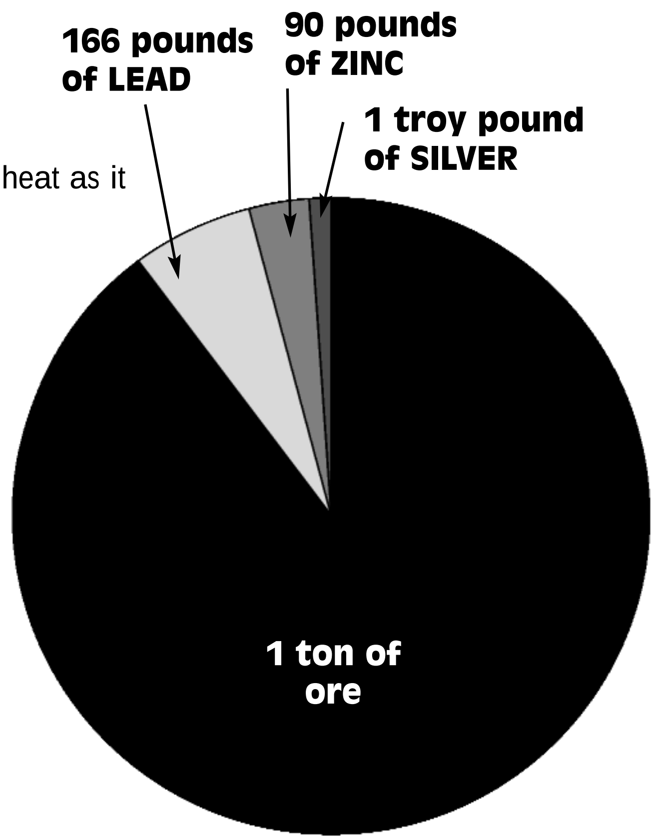


Fig. 8.4 For each ton of ore extracted, there were 166 pounds of lead, 90 pounds of zinc, and only about one troy pound of silver.

NOTES

Checkpoint

Chemical change is a primary way in which matter on earth changes from one form to another. Energy is involved in chemical and physical changes.

Underline the physical change process in a Park City mill that requires energy. Draw a rectangle around the chemical change process in a smelter that requires energy.

Heat **Crushing** **Gravity**

When chemical or physical changes occur, the total amounts of matter and energy remain the same. This is the **law of conservation** of matter and energy.

Using symbols, write a sentence demonstrating this law as lead sulfide and waste rock work their way through the mill (physical change).

Write a chemical equation demonstrating this law in which lead and carbon monoxide are the products of a blast furnace process (chemical change).

LESSON 8

More Questions

In a chemical change, the identity of the atoms does not change, but the atoms are recombined into a new substance. Evidence for a chemical reaction may include color change, gas given off, and heat or light given off or absorbed.

Write a chemical equation in the smelting process showing how lead sulfide and oxygen recombine into new substances, one of which is the gas sulfur dioxide.

Describe in your own words how lead was separated from lead sulfide during the smelting process.

Checkpoint

Answer Guide

Chemical change is a primary way in which matter on earth changes from one form to another. Energy is involved in chemical and physical changes.

Underline the physical change process in a Park City mill that requires energy. Draw a rectangle around the chemical change process in a smelter that requires energy.

Heat   **Crushing**   **Gravity**

When chemical or physical changes occur, the total amounts of matter and energy remain the same. This is the **law of conservation** of matter and energy.

Using symbols, write a sentence demonstrating this law as lead sulfide and waste rock work their way through the mill (physical change).

Waste rock and PbS + crushing and gravity reproduction = PbS + waste rock

Write a chemical equation demonstrating this law in which lead and carbon monoxide are the products of a blast furnace process (chemical change).

$PbO + C = Pb + CO(g)$

Answers to More Questions

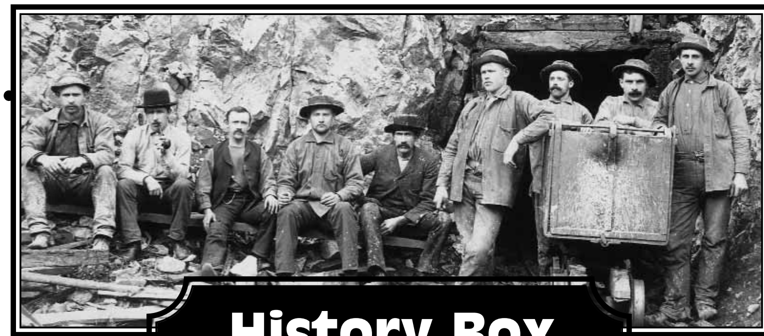
In a chemical change, the identity of the atoms does not change, but the atoms are recombined into a new substance. Evidence for a chemical reaction may include color change, gas given off, and heat or light given off or absorbed.

Write a chemical equation in the smelting process showing how lead sulfide and oxygen recombine into new substances, one of which is the gas sulfur dioxide.

$2PbS + 3O_2 =$
$2PbO + 2SO_2(g)$

Describe in your own words how lead was separated from lead sulfide during the smelting process.

The lead sulfide is combined with oxygen. This chemical process produces lead oxide. Lead oxide is reduced with carbon to produce pure lead. These changes occur in the smelter operation.



History Box

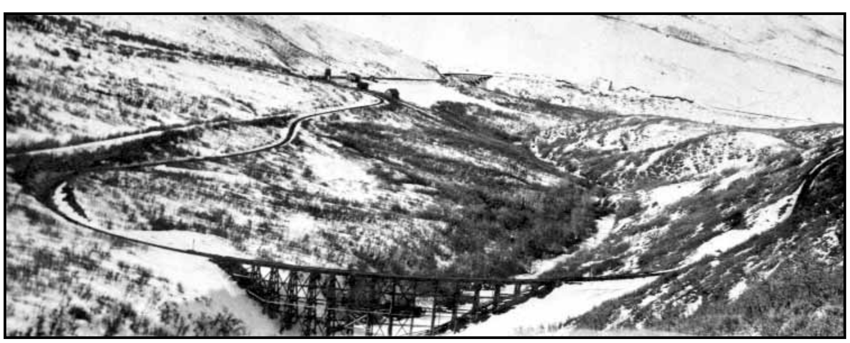
Railroads Made Mining Successful

By 1881, the first railroad had come to Park City. The Utah Eastern, which became a branch of the Union Pacific, came from Echo. It was almost ten years before another rail line would arrive in town. John W. Young, son of Brigham Young and the head of the Salt Lake & Eastern Railway, realized the need for a direct rail line between Salt Lake City and Park City, and so he began laying tracks up the rugged, difficult terrain of Parley's Canyon.

A passenger train of the Denver and Rio Grande Railroad is stopped at the Utah Central Depot.

By the time Young's railroad was completed in 1890, it was a branch of the Utah Central Railway and even later the Denver and Rio Grande. Utah Central's steam locomotive had a cow catcher in front, followed by two leading wheels, which in turn were followed by six driving wheels. Wood for the locomotive's boiler was stacked in the tender, the car right behind the locomotive.

The Utah Central provided a direct route for the mine companies to ship their ore to the Murray smelters. Transportation time was cut down to two hours, half the time it took going via Echo, and shipping ore became cheaper. Without the railroad, mining in Park City would have been much less productive.



Today, you can hike or bike the railroad bed of the Utah Central Railroad, by taking the Union Pacific rail trail.

The Denver and Rio Grande Railroad came up Parley's Canyon.

LESSON 9

Culminating Activities

Summarize with students what they have learned about mining in Park City. Give students a choice of the following culminating activities.

1. Write a children's book describing the history of Park City's mines. This can be a contest and the best children's books will be exhibited at the Park City Museum.

2. Create a cartoon strip or a short skit depicting some of the topics and characters you studied. Think of costumes, settings and various props that can be used.
   Examples:

   Create characters of workers in the Silver King mill, and show how ore was concentrated in one of Park City's mills. Explain how the ore was transported off the mountain to the smelters.

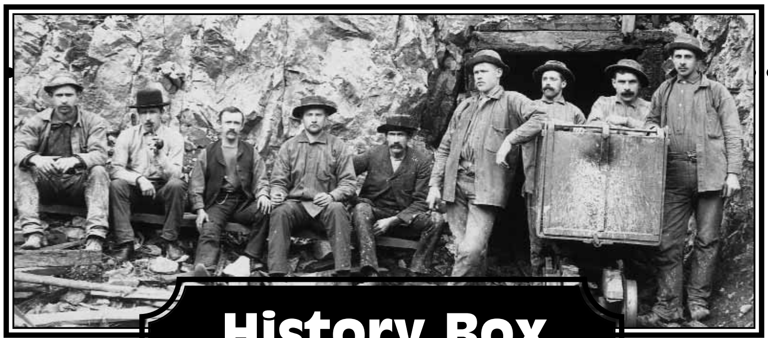
   Imagine the character of a powder monkey, the miner who set dynamite. Depict a story of how he worked in the mine.

   Research the story of the Daly-West mine disaster in the book "Treasure Mountain Home" by George A. Thompson and Fraser Buck.

3. Develop a Map, a Poster, or a Power Point presentation explaining one of the scientific topics you studied. Be sure to include historical facts in your presentation.

4. Build a model of a mill, a mine, or a smelter. Contact the Museum for the models to be exhibited in a temporary exhibit in the museum.

5. Use the History Box "Why is Park City a Ski Town?" and prepare a report on how Park City developed from a mining town into a skiing town.



History Box

Why is Park City a ski town?

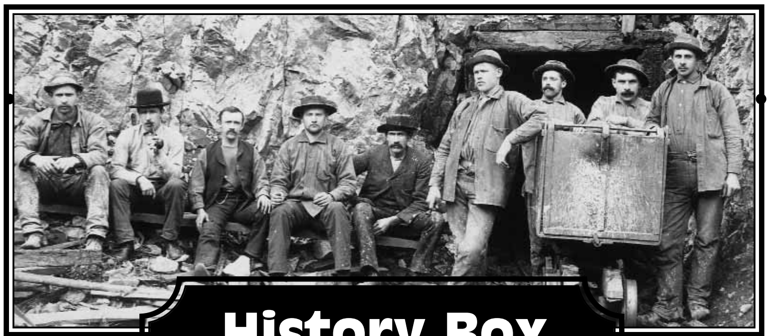
"Sports fiends may speak about their Sun Valley—we have a Sun Valley right here in Utah, under the name Park City—but we have yet to make them believe it."
-- Park Record, 1937

In the 1950s, nearly all of Park City's mining claims were merged into United Park City Mines (UPCM). Even though there was still a lot of ore in the mountains, development costs were too high to access and extract the silver ore. Mining no longer provided the economic stability the town needed to survive.

The board of UPCM, which included Jack Gallivan of the Salt Lake Tribune, had an idea to create a ski resort on the land they owned above the mines. Skiing had always been a popular pastime in Park City, and UPCM believed that it would revive the economy enough to save the town until metal prices rose again and mining could continue. The only problem was money. In a town with no real economy, they debated on how to fund the $2 million project.

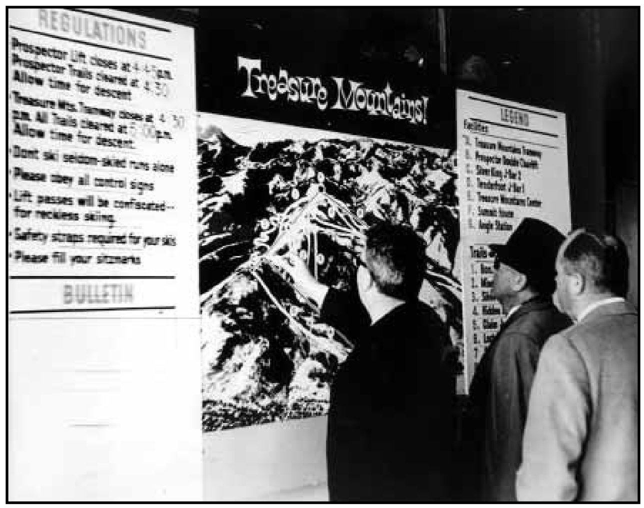
The 1962 luncheon with President John F. Kennedy.

In 1962, Gallivan was invited to Washington D.C. to attend a luncheon with President John F. Kennedy, along with other members of the Utah press. When Kennedy asked if there was anything he could do for Utah, Gallivan mentioned the problem of Park City's economy. The president told his press secretary to "take care of it." Two weeks later, UPCM received a low-interest Area Redevelopment Administration loan which would help UPCM to build the first modern-day ski resort in town.

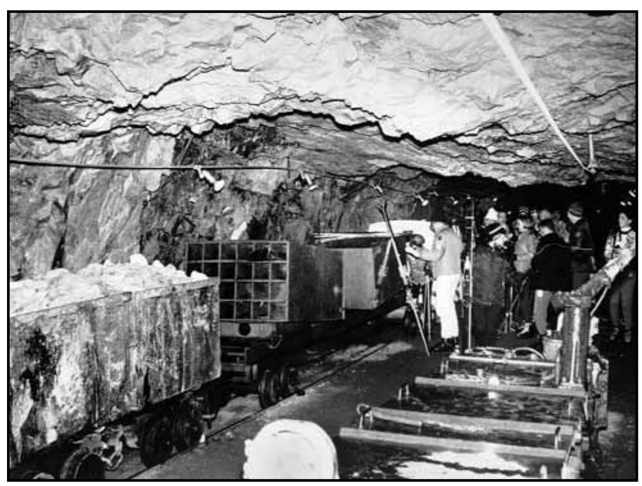


History Box

Treasure Mountains (now Park City Mountain Resort) opened on December 21, 1963. As a way to bridge the town's unique mining history with the new resort, they developed the skier subway. By building special passenger cars to travel along the old ore car rails, skiers could travel three miles into the mountain to Thaynes shaft. From there, they would ride in the mine cages 1,800 feet up to the surface. Because it took an hour to get to the top of the mountain, the skier subway was only operating for a few years. However, it remained a tourist attraction and was part of an underground museum until 1978. Today the skier subway car can be seen at the Park City Museum.



Three men study a map of Treasure Mountains Resort.



Skiers inside the Spiro Tunnel unload their skis from the Skier Subway.

APPENDIX

Bonus Assignment

Chemical Profiles

	Molecular formula	Brief Description	Appearance	Uses (name at least 3)
Silver				
Lead				
Copper				
Zinc				
Galena				
Sphalerite				
Sulfuric acid				
Nitric acid				
Nitrogly-cerine				
Glycerine				
Calcium carbide				
Acetylene				

For help with the Bonus Assignment, use your Science textbook and do research on the Internet.

Helpful websites are:

www.wikipedia.org
www.galleries.com/minerals/by-name.htm
www.mii.org

GLOSSARY

Assay - method used to determine the contents of ore

Assayer - worker who crushes rock into fine material and separates valuable metals from waste rock

Blast furnace - oven used to create pure metals by blowing oxygen into its base

Blasting cap - a device used to detonate dynamite

Boiler - large water tank with fire underneath it

Boiling point - temperature at which a liquid boils (100° C at sea level)

Burner tip - where flame is when lamp is in use

Cage - a kind of elevator that is connected to a hoist and travels inside a mine shaft

Cam - a rotating piece of machinery

Carbide chamber - holds carbide rocks

Chemical change - primary way in which matter on earth changes from one form to another

Chemical property - chemical characteristics of a mineral

Concentrating table - rectangular edged piece of metal that separates valuable minerals from tailings

Crystallize - to bring to definite and permanent form

Double jacking - two miners working together with 8 pound hammer and drill steel to make hole in rock for dynamite

Drift - horizontal tunnel inside a mine

Dynamite - a mixture of nitroglycerin and silica

Erosion - process of wearing away of earth through air, water, wind

Extrusive rock - rock that has formed after hot magma from inside the Earth has flown out onto the surface as lava and then cooled off

Fault lines - cracks and fissures formed by magma pressure

Felt - allows gas to pass up from carbide chamber, keeps used carbide in chamber

Fossil - remains of an animal or plant from an earlier era preserved inside a rock

Fossiliferous - a rock or other deposit that contains fossils

Fuse - a thin rope with a gunpowder core that burns slowly

Galena - metallic, gray, lead bearing rock

Gases - products of a dynamite explosion that expand rapidly and whose pressure causes rock to break apart

Gas pipe - tube that gas blows out of, part of carbide lamp

Geologic map - map showing the structure and rock formations of the earth in a given region

Glycerin - a clear, somewhat thick liquid, sometimes used in soap

Gravel - a mixture of small, rounded stone, often with sand

Grizzly - series of parallel metal bars placed several inches apart

Gun powder - an explosive invented in the 8th century

Hard rock mining - process whereby ore is extracted by underground methods

Hoist - the machinery that lifts the cage in a mine shift

Hoist man - miner who lifted cage to the surface

Hydrophobic - resistant to water

Hydrothermal - hot igneous rock - rock formed by heat

Igneous rock - rock formed by heat

Intrusive rock - rock that has formed from magma below the surface of the Earth, and then breaks through preexisting rock formation

Iron pyrite - “fool's gold”: mineral that only appears to contain gold because of its color and metallic luster

Jaw crusher - machine that reduces ore from 10 inches to less than 2 inches

Law of Conservation - matter and energy remain the same when chemical and physical changes occur

Limestone - rock formed of calcite and sea animal shells

Locomotive - train engine

Lode - see Vein

Magma - mass of molten rock from which igneous rock is formed

GLOSSARY

Metamorphic rock - rock formed by force, heat, pressure, moisture, etc.

Milling process - involves size reduction to separate minerals from waste rock followed by separation based on gravity, or other selective method

Mineral - naturally occurring solid that has a crystal structure and a definite chemical composition

Mineralization - process by which minerals crystalize out of the hot water created by the magma

Mucker - miner who shovels rock into ore cars

Nitroglycerin - a highly unstable mixture of glycerin and acids

Ore - a rock containing a valuable mineral

Outcrop - exposure of a vein at or above the surface of the ground

Physical property - physical characteristics of a mineral

Piston - a plug inside a chamber that moves back and forth

Placer - sand banks

Placer deposits - place where nature broke up rock over eons of time and concentrated heavy minerals

Powder monkey - miner who handled dynamite

Pressure - force

Propellant - a material that moves an object, often with pressurized gas

Pyrite - metallic, pale-yellow iron-sulfide rock

Quartz - S_1O_2 hard, semi-transparent mineral

Reflector - projects light

Rod and piston - makes wheels or a drum turn

Safety valve - releases pressure before pressure becomes too great

Sandstone - sedimentary rock formed of mostly quartz

Sediment - matter that settles to the bottom of a liquid

Sedimentary rock - fragmentary material deposited by water or air

Shale - rock formed from clay and mud

Silica - something like sand

Silt - sediment consisting of fine particles of rock and soil carried in water

Single jacking - one miner uses a 4 pound hammer and drill steel to make holes in rock for dynamite

Sinter - hard cake-like substance made out of lead oxide after roasting

Smelter - furnace in which minerals are melted down

Spitter - fuse

Stabilize - to make a dangerous material less dangerous

Stamp mill - machinery that reduces the size of ore to less than an inch

Steam - vaporized water

Sticking tommy - metal device to hold candle

Striker assembly - has flint rock inside, creates a spark, is attached to reflector

Suction - creation of a partial vacuum or low pressure

Tailings - waste rock particles

Tappet - a lever moved by another piece (cam)

Tender - railroad car right behind the locomotive carrying fuel

Troy ounce - a measuring system used for precious metals (12 troy ounce = 1 troy pound; 1 troy ounce is 10% heavier than our standard ounce)

Vacuum - area of low pressure or no air

Valve control - moves along grooves (control slots), sets rate of water flow in carbide lamp

Vein - an area where a particular mineral is found, also called Lode

Water chamber - holds water inside carbide lamp

Water door - small lid with hinge, lifts up

Water valve - hole where water drips onto carbide rocks

Weight - any object or mass that weighs a specific amount

Resources

Books

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Science Explorer Inside EARTH. 2005. Prentice Hall Inc.

Websites

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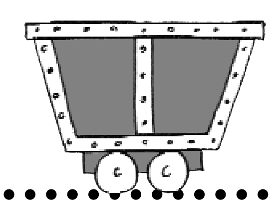
Wikipedia	http://www.wikipedia.org
Mineral Gallery	http://www.galleries.com/minerals/by-name.htm
How Stuff Works	http://www.howstuffworks.com/
Park City Historical Society & Museum	http://www.parkcityhistory.org
Utah Museum of Natural History	http://www.umnh.utah.edu/
Utah State Historical Society	http://history.utah.gov/

Museums

Park City Historical Society & Museum - exhibits, research library and online resources

Utah Museum of Natural History - exhibits and online resources

Utah State Historical Society - research center and online resources



PARK CITY
MUSEUM